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ALGAL COMMUNITIES OF EXPOSED AND PROTECTED MARINE WATERS OF BATANGAS AND BATAAN*

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FOURTEEN PLATES AND ONE TEXT FIGURE

ABSTRACT

Sixty-nine species of the marine benthic algæ of the exposed and protected waters of Batangas and Bataan were studied and classified. Artificial keys were prepared to differentiate 28 species of Chlorophyta, 14 of Phaeophyta and 27 of Rhodophyta. Every species is represented by a photograph, a brief characterization and general ecological observations. In the exposed littoral zones, Batangas has 24 per cent more algal species than those found in Bataan. Both are open to the clear waters of East China Sea which flows continuously bringing along dissolved nutritive inorganic salts.

It is interesting to note that the protected waters of Batangas yield 61 per cent more species than the algal species collected in the protected waters of Bataan. Discharge of pollutants from the oil refinery at Limay, Bataan, must have caused the unusually poor growth of the algæ. Such pollution is not present in the protected waters of Batangas. In addition, the greater part of the protected littoral zones of Bataan is characterized by dark fine sandy-muddy substratum and slightly turbid water throughout the year. That of the protected littoral zone of Batangas is generally clear with rocky, sandy-muddy substratum.

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The study includes three species of Phaeophyta and four of Rhodophyta which are potentially good sources of alginic acid, alginates, agar and carrageenan. *Sargassum polyceratium*, *Sargassum* sp., *Hydroclathrus clathratus*, *Eucheuma muricatum*, *Gracilaria eucheumoides*, *G. verrucosa* and *Halymenia durvillaei* are being studied in the National Institute of Science and Technology for their chemical and nutritive values.

I. INTRODUCTION

The first year of the investigation was the study of the exposed marine benthic algæ of Calatagan and Nasugbu, Batangas and the protected marine algæ of Limay and Orion, Bataan. The second year dealt with the study of the exposed marine algæ at Moron, Bataan, and the protected algæ of Botong, Taal, Batangas The observations during the 2 years of investigation showed undoubtedly that more marine algæ live in exposed waters of both Bataan and Batangas than in protected waters.

The study furnishes an inventory of the more common marine benthic algæ in the exposed and protected waters along the coast of Batangas and Bataan. This will be an important guide and reference to further algological study of the regions besides supplying partly the materials needed by teachers and students in biology. Of the algal specimens thriving in exposed waters, 10 species are potentially good sources of alginic acid, alginates, agar and carrageenan. Certainly, the findings would be useful to those who would venture into a new industry utilizing local seaweeds. The National Institute of Science and Technology was already furnished with raw materials of some of these algæ primarily for study of their chemical and nutritive constituents.

Furthermore, the work would serve biologists in studies of marine communities and phycologists in the identification of materials of comparison with named specimens.

There are very limited studies of the marine algæ of the Philippines which are relevant to the present work. Velasquez (1953) presented in the Eighth Pacific Science Congress a preliminary study of the marine algæ of the Philippines. This was supplemented with a brief information of the history and distribution of the local materials. In 1959, Gilbert published an annotated checklist of the Philippine Marine Chlorophyta. This was followed by Meñez's study (1961) of at least 72 species of marine algæ of the Hundred Islands, Pangasinan Province. Two years later in 1963, Galutira and Velasquez described 19 species of edible algæ in the province of Ilocos Norte.

The open markets in the Philippines have always fresh seaweeds for sale from late December to early April. There are also many species sold in dried forms in Chinese stores. In fact, crude agar is prepared and distributed for local consumption by several factories. At least two species of *Eucheuma* are being cultured to boost the local production of raw algal materials that are processed abroad for carrageenan. In Japan, 45 per cent of their marine algæ are preserved for food and other finished products from algal industries.

II. THE COLLECTING SITES

Nasugbu and Calatagan in Batangas Province, the sources of exposed marine benthic algæ, lie approximately 14° 5' North latitude and 120° 38' East Longitude and 13° 5' North Latitude, 120° 40' East longitude, respectively. Nasugbu is on the north-

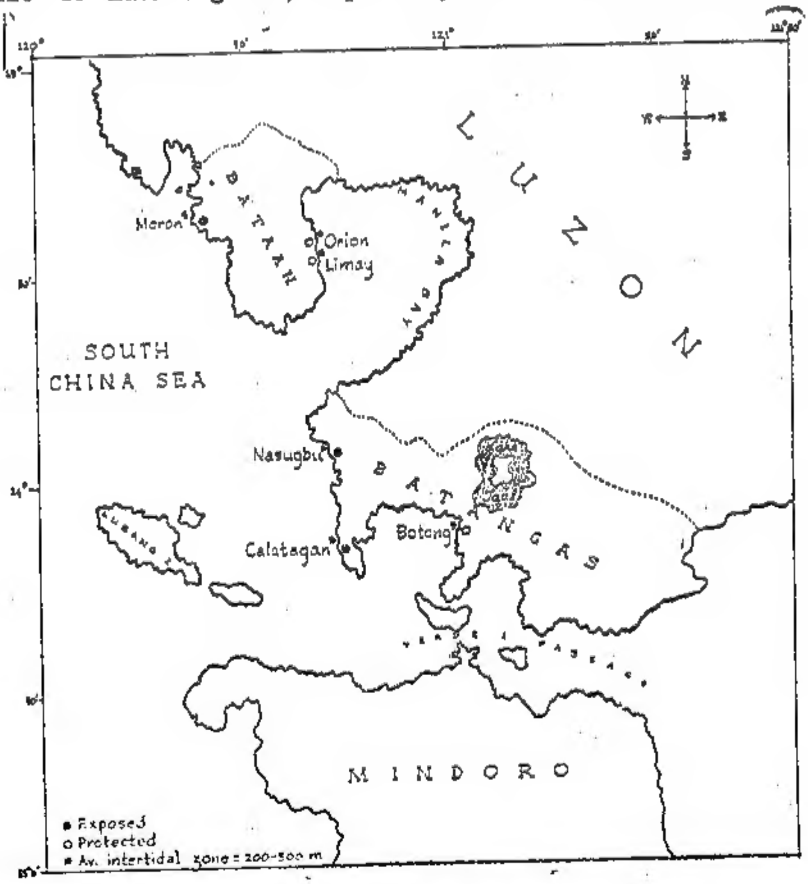

FIG. 1. Collecting stations of exposed and protected shores.

western part while Calatagan is at the western side of Batangas. Both localities have identical shorelines, exposed to East China Sea with an intertidal collecting littoral zones averaging from 400 to 600 meters seaward.

Orion and Limay in Bataan Province lie about 14° 35' North latitude, 120° 32' East longitude and 14° 33' North latitude, 120° 35' East longitude, respectively. Both Orion and Limay are located approximately on the east-southeastern side of Bataan. Their shores face the western part of Manila Bay.

In the second year, the sites of investigation were reversed. The exposed waters of Moron, Bataan and the protected waters of Botong, Taal, Batangas were studied. Moron lies approximately 14° 39' North latitude and 120° 17' East longitude. The littorral collecting zone is exposed to East China Sea similar to the exposed shores of Nasugbu and Calatagan. It has a wide collecting zone about 600 meters seaward.

Botong, Taal in Batangas lies approximately 13° 46' North latitude and 120° 48' East longitude. Its collecting zone revealed more algal species present than the corresponding protected waters of Bataan.

Tables 1 and 2 below are comparisons of the algal groups collected and studied in the exposed and protected waters of Batangas and Bataan during 2 years work.

TABLE 1.—*Marine benthic algæ collected in the exposed and protected waters of Batangas and Bataan in the first year of investigation.*

Collecting areas	Groups of algae			Remarks
	Chlorophyta	Phaeophyta	Rhodophyta	
Exposed waters: Calatagan and Nasugbu, Batangas	33	16	40	These algae constitute the basis of the study including those of Table 2 below.
Protected waters: Orion and Limay, Bataan	8	3	5	

TABLE 2.—*Marine benthic algæ collected in the second year.*

Collecting areas	Groups of algae			Remarks
	Chlorophyta	Phaeophyta	Rhodophyta	
Protected waters Botong, Taal, Batangas	10	9	22	Phaeophyta and Rhodophyta for the protected waters of Batangas are more numerous than the corresponding algae in the protected waters of Bataan.
Exposed waters: Moron, Bataan	24	11	33	

III. SOME ECOLOGICAL FACTORS

The exposed shorelines of Batangas and Bataan are both facing the East China Sea. The protected shorelines of Bataan face the eastern side of Manila Bay while that of Botong, Taal, Batangas is protected by the northern part of Mindoro, Cape Santiago and Maricaban, island municipality of Batangas in the western portion of Verde Island Passage. More rain during July to November does not seem to have significant effect upon the algal vegetation under study. The annual average temperature is 26.9°C. The substrata of the open waters in the two provinces are similarly extended to 400 to 600 meters seaward. The littoral collecting zones are mostly sandy-muddy substrata, with the ordinary rocks and boulders where benthic algæ can grow abundantly. There are also shells and hard-fragmented coral parts scattered here and there which are additional favorable habitats of the algæ. The fringes of the collecting zones towards the deeper water are similarly grown with hard corals that protect the zones from too much disturbances of strong waves. The water is clear almost throughout the year and the current stabilizing the temperature and distribution of inorganic materials is continuously brought about by the rise and fall of water during tides.

On the other hand, the protected waters of Limay and Orion do not move as fast as the open waters in the two provinces because of the land protection of Bataan and the effect of the western part of Manila Bay. In fact, the substrata are usually muddy and intermixed with fine blackish sand, becoming turbid during windy seasons. The dark sand somewhat absorbs the light aside from the turbidity in the locality. Pollution from an old refinery at Limay and the traces of organic and inorganic pollutants from Manila Bay inhibit the growth of algal species thriving at the place. These pollutants tend to weaken and shorten the longevity of the microorganisms which are the basic constituents of the food chain.

At Botong, Taal in Batangas, the collecting zone is protected partially by the cape at the southern tip of Calatagan and Maricaban Island, municipality of Batangas. On the other hand, the substrata are sandy-muddy over scattered shells, and sand and rocks which provide attachment to the algæ. Pollution is very much less, the oil discharge is notably absent, hence very much less, the oil discharge is notably absent, hence very much more

algæ could thrive in this habitat than the protected waters of Bataan.

Differences in monthly rainfall and daily temperature variation of the shorelines of Batangas and Bataan do not seem to affect the growth of the algæ in those regions.

IV. CLASSIFICATION OF THE BENTHIC ALGAE

The marine benthic algæ were studied largely from their external characteristics supplemented by the reproductive features of some species whenever necssary. Most of the algæ exhibit the characteristics which are quite familiar observations in many species studied in other localities. This facilitates the construction of a simple artificial classification which is important in order to furnish a first hand guide to those who are interested to know the marine algæ growing in their localities. It will be a practical handbook to biology teachers and students, and to others interested to collect seaweeds for instruction in the laboratory. It will also serve as a handy reference to the biologists and others who may be interested in industry.

All the marine algæ collected can be classified easily under Cyanophyta (blue-green algæ), Chlorophyta (green algæ), Phæophyta (brown algæ), and Rhodophyta (red algæ). But while their nature of calcification and sufficient familiarity to their green, brown and red pigments seem to have guided the separation of the three big algal groups, it will appear that the work had been more dependent upon the definite forms of the species, various habits and habitats. Whenever the algal species is too small to exhibit its external morphology, then the cell forms and their characteristics had to be examined under the microscope.

All preserved specimens are kept in the Department of Botany, University of the Philippines, Quezon City. The distribution records list all specimens studied with the herbarium number appearing before the locality of collection.

Uncommon species with insufficient information have not been included. They will be accommodated in another paper as soon as enough materials for further study are available. Thirty-five species of algal epiphytes were studied and treated in a separate paper. Eight species of the phylum Cyanophyta will be presented in another publication; they constitute also an important part of the work due to their significance in the pollution of the seas.

A simple glossary was prepared for those not familiar with the terms used in the key.

Key to Phyla

1. Thallus simple to complex, possessing green pigments, chlorophyll *a* and *b* in the chloroplastids .... Phylum Chlorophyta
   Thallus mostly complex, possessing different pigments 2
2. Brown color due to pigment fucoxanthin in chromatophores. Phylum Phæophyta
   Red color due to pigment phycœrythrin in chromatophores. Phylum Rhodophyta

CHLOROPHYTA

Photosynthetic pigments chlorophyll *a* and chlorophyll *b* are present with true starch as reserved food. Vegetative body is unicellular or multicellular; the cells are uni- or multinucleated. Specimens studied are filamentous or with thallus of definite and indefinite shape.

Asexual reproduction is by zoospores with two or four anterior flagella of equal length; sexual reproduction is either isogamous, heterogamous and oogamous. Gametes are biflagellated. The zygote which is generally protected by a thick wall usually enters a period of rest; upon germination it divides first by meiosis to maintain haploidy in the vegetative body. Some species exhibiting alternation of generation conspicuously have the zygotes germinating directly into diploid plants.

Key to the species of Chlorophyta

1. Plant body calcified 2
   Plant body not calcified 11
2. Thallus cylindrical 3
   Thallus not cylindrical 4
3. Thallus club-shaped, short, at mostly 3.3 cm tall . *Neomeris annulata*
   Thallus club-shaped, much taller, up to 8 cm tall. *Halicoryne wrightii*
4. Thallus made of umbrellalike rays 5
   Thallus flat, single or segmented 6
5. Stipe fine and short, up to 1 cm tall ...... *Acetabularia calyculus*
   Stipe coarse and much taller, up to 7 cm tall .... *A. major*
6. Thallus solitary, erect and flabellate 7
   Thallus of numerous segments borne in definite stems 8
7. Stipitate, holdfast attached generally to shells or sand. *Udotea orientalis*
   Not stipitate, holdfast deeply buried usually in sandy-muddy substratum .... *Avrainvillea erecta*

8. Segments small, up to 0.9 cm diameter 9
Segments large, 2.5 cm average diameter 10

9. Segments small, 4 to 6 mm diameter, attached in a plane from
regular conspicuous stems .... *Halimeda velasquezii*
Segments larger, 6 to 9 mm diameter, attached without order from
regular conspicuous stems .... *Halimeda velasquezii*
irregular inconspicuous stems .... *H. opuntia*

10. Segments generally subcuneate, oval above .... *H. tuna*
Segments generally rounded, mostly reniform above .. *H. macroloba*

11. Thallus simple, uniseriate 12
Thallus multiseriate in matured specimens 13
Thallus variously developed 14

12. Filaments 560 to 600 μ diameter .... *Chaetomorpha crassa*
Filaments 50 to 65 μ diameter .... *C. gracilis*

13. Thallus often intestiniform, generally 10 cm long, 5 cm wide, less
branching .... *Enteromorpha intestinalis*
Thallus not intestiniform, very much shorter, repeatedly branching.
E. clathrata

14. Axis of thallus erect 15
Axis of thallus inconspicuous 17

15. Erect thallus bearing pinnate branchlets ...... *Bryopsis plumosa*
Erect thallus clavate 16

16. Several clavate, solitary thallus arising from a base.
Bœrgesenia forbesii
Numerous clavate thalli in irregular branches *Valonia aegagropila*

17. Thallus spherical or hemispherical 18
Thallus different 19

18. Thallus large, hallow, variously torn when mature.
Dictyosphaeria cavernosa
Thallus much smaller, 0.8 cm diameter, not torn .. *D. vanbossea*

19. Growth of thallus foliose 20
Growth of thallus not foliose 22

20. Foliose development much larger, up to 17 cm diameter, 2 cells
thick .... *Ulva lactuca*
Foliose development much smaller, 1 cell thick 21

21. Cell organization solid, a continuous expanse up to 3 cm diameter.
Anadyomene stellata
Cell organization not solid, skeletonous expanse indefinite.
Microdictyon agardhianum

22. Thallus of separate independent filaments from a common base.
Chlorodesmis comosa
Thallus of bundled interlacing filaments, solid, scandent or decumbent 23

23. Growth of thallus regularly dichotomous, spongy .. *Codium tenue*
Growth of thallus creeping, indefinite, foliar branches erect .. 24

24. Thallus slender, foliar branches long-stiped and abruptly peltate. *Caulerpa peltata*
 Thallus stout, erect foliar branches short-stipped, not peltate . 25
25. Erect foliar branches closely pinnate, slightly curved above. *C. sertularioides*
 Erect foliar branches differently developed 26
26. Erect foliar branches usually crowded, with spherical stalk branches.
 Erect branches differently developed 26
 C. racemosa
 Erect foliar branches generally slightly twisted, with serrated margins .... *C. serrulata*

Order ULOTRICHALES

FAMILY ULVACEAE

Genus ULVA Linnaeus, 1753

ULVA LACTUCA Linnaeus. Plate 1, fig. 1.

SMITH (1944) 45, pl. 3, figs. 6-7; TAYLOR (1960) 65.

Plants attached by tiny inconspicuous holdfasts on rocks and other substrata along shallow open littoral zones; thallus green and generally ovoid, soft and undulate, sometimes cut and torn on maturity due to wave action. Edible species are collected in clean water along open shores.

Distribution: 57 Bagong Silang, Calatagan, Batangas, near lighthouse, in shallow littoral zone, June 8, 1968.

Genus ENTEROMORPHA Link, 1820

ENTEROMORPHA INTESTINALIS (Linnaeus) Link. Plate 1, fig. 2.

SMITH (1944) 49, pl. 5, figs. 4-6; TAYLOR (1960) 62.

Plants gregarious, at first attached becoming generally free-floating on maturity; thallus long and narrow, green to yellowish-green and intestiniform. Luxuriant growth in thick floating masses are usually observed at mouths of fresh-water streams that become brackish on emptying along shores.

The plants are cultivated for food of milkfish in brackish ponds.

Distribution: 6 Bagong Silang, Calatagan, Batangas, near lighthouse, attached to rocks on upper littoral zone, May 23, 1968; 135 Limay, Bataan, October 1, 1968.

ENTEROMORPHA CLATHRATA (Roth) J. Agardh. Plate 1, fig. 3.

SMITH (1944) 51; TAYLOR (1960) 58.

Young plants usually attached, becoming free-floating entangled masses; light green and repeatedly branching in matured specimens. Common in quiet, warm, brackish waters.

Distribution: 33 Bagong Silang, Calatagan, Batangas, near lighthouse, in upper littoral zone, May 23, 1968.

Order CLADOPHORALES

Family CLADOPHORACEAE

Genus CHAETOMORPHA Kuetzing, 1845

CHAETOMORPHA CRASSA (C. Agardh) Kuetzing. Plate 1, fig. 4.

DAWSON (1954) 386; SEGAWA (1956) 11, fig. 51; TAYLOR (1960) 12.

Plants entangled, filaments 560 to 600 micra in diameter; cells generally longer than broad, characterized by thick cell walls. Usually in shallow water.

The plants are cultivated as excellent food for milkfist in brackish ponds.

Distribution: 21 Bagong Silang, Calatagan, Batangas, near lighthouse, in shallow littoral zone, May 23; 228 Buaya Pt., Calatagan, Batangas, entangled on leaves of eel grasses, February 2, 1969; 402 Panibatuhan, Moron in Bataan, October 18, 1969.

CHAETOMORPHA GRACILIS Kuetzing. Plate 2, fig. 5.

TAYLOR (1960) 70.

Plants floating, loosely entangled and composed of cylindrical filaments; rectangular cells 50 to 65 micra in diameter, 2 to 4 diameters long.

Distribution: 101 Wawa, Nasugbu, Batangas, September 1, 1968.

Order SIPHONOCLADIALES

Family DASYCLADACEAE

Genus NEOMERIS Lamouroux, 1816

NEOMERIC ANNULATA Dickie. Plate 2, fig. 6.

SEGAWA (1956) 13, fig. 17; TAYLOR (1960) 101, pl. 15, fig. 5; pl. 6, figs. 4-6.

Plants club-shaped and solitary, or densely gregarious; individual plants up to 33 mm tall, 3 to 5 mm diameter; much calcified at base, becoming less towards tip.

Of general distribution, a few solitary individuals found on rocks along shallow littoral zones.

Distribution: 87 Pulong Bato, Bataan, attached to rocks on shallow intertidal zone, August 5, 1968; 142 Limay, Bataan, October 1, 1968; 165 Balaytigue, Nasugbu, Batangas, November

27, 1968; 325 Sabang, Moron, Bataan, October 16, 1969; 403 Panibatuhan Moron, Bataan. October 18, 1969; 503 Kapayan Beach, Moron, Bataan, May 16, 1970; 524 Botong, Taal, Batangas, May 16, 1970.

Genus HALICORYNE Harvey, 1859

HALICORYNE WRIGHTII Harvey. Plate 2, fig. 7.

SEGAWA (1958) 13, fig. 59.

Plants solitary or in clumps, growing on shells, small and big rocks or sandy bottom; slender and club-shaped forms up to 8 cm tall; green when young, becoming pale green to white on maturity; very highly calcified.

Distribution: 474 Panibatuhan, Moron, Bataan, May 5, 1970.

Genus ACETABULARIA Lamouroux, 1816

ACETABULARIA CALYCULUS Quoy and Gaimard. Plate 2, fig. 8.

SEGAWA (1956) 13, fig. 62; TAYLOR (1960) 105.

Stipes slender, 1.5 to 3.0 cm tall, disc cup-shaped, generally 6 mm in diameter. Growing under shaded situation in rock crevices, not as conspicuous as other algæ.

Distribution: 12 Bagong Silang, Calatagan, Batangas, near lighthouse, forming limited beds protected from strong action of waves, May 25, 1968; 159a Bagong Silang, Calatagan, Batangas, October 29, 1968

ACETABULARIA MAJOR Martens. Plate 2, fig. 9.

GILBERT & DOTY (1969) 126, fig. 17.

Plants solitary and conspicuous umbrellalike, sometimes growing together luxuriantly on shells and small stones, seen during low tides along shallow littoral zones of protected shores. Specimens in deeper habitats grow longer stipes.

Distribution: 256 Bagong Silang, Calatagan, Batangas, April 19, 1968.

Family VALONIACAE

Genus VALONIA Ginnani, 1757

VALONIA AEGAGROPILA C. Agardh. Plate 3, fig. 10.

SEGAWA (1956) 6, fig. 22; TAYLOR (1960) 111, pl. 7, fig. 6; TRONO (1968) 156.

Plants usually attached, forming masses of short, stout, dichotomously branching filaments; matured filaments forming large masses 4 to 20 cm in diameter.

Luxuriant growth of this species are usually attached in protected rocky shorelines.

Distribution: 227 Buaya Pt., Calatagan, Batangas, found entangled in root braces of mangroves, February 2, 1969; 291 Moron, Bataan, June 12, 1969.

Genus DICTYOSPHAERIA Decaisne, 1842

DICTYOSPHAERIA CAVERNOSA (Forsskaal) Boergesen. Plate 3, fig. 11.

SEGAWA (1956) 6, fig. 23, TAYLOR (1960) 116, pl. 7, fig. 7.

Plants sessile. green and solid when young, later hallow; generally 2 to 5 cm in diameter; largest diameter observed 10 to 20 cm; roughly lobed with tissues torn and deformed in deeper habitats. Cells large, generally hexagonal, others ordinarily angular.

Distribution: 20 Bagong Silang, Calatagan, Batangas, near vicinity of lighthouse, attached to rocks, May 23, 1968; 117 Wawa, Nasugbu, Batangas, September 1, 1968, 231 Buaya Pt., Calatagan, Batangas, February 2, 1969; 275 Moron, Bataan, June 12, 1969; 487 Panibatuhan, Moron, Bataan, May 5, 1970.

DICTYOSPHAERIA VANBOSSAE Boergesen. Plate 3, fig. 12.

TAYLOR (1960) 116.

Plants small, usually solid and sessile, generally up to 8 mm in diameter; vegetative body composed of angular, generally hexagonal cells.

Distribution: 13 Bagong Silang, Calatagan, Batangas, near lighthouse in shallow portion of littoral zone, May 23, 1968; 392 Panibatuhan, Moron, Bataan, October 18, 1969.

Genus MICRODICTYON Decaisne, 1839

MICRODICTYON AGARDHIANUM Decaisne. Plate 3, fig. 13.

FRITSCH (1935) 433, fig. 140, Vol. II

Plants sessile, microscopic, spongelike masses composed of fine short filaments branching in all directions; individual cells rectangular and conical at free ends.

Distribution: 23 Bagong Silang, Calatagan, Batangas, near lighthouse in deeper portion of littoral zone, May 23, 1968; 105 Wawa, Nasugbu, Batangas, September 1, 1969.

Genus CHLORODESMIS Harvey & Bailey, 1851

CHLORODESMIS COMOSA Harvey and Bailey. Plate 3, fig. 14

SEGAWA (1956) 18, fig. 83; TRONO (1968) 172.

Plants bright green, erect filaments dichotomously branching with felted basal growth attached strongly to rocks in deep water exposed to wave action. Common in collection but rarely abundant.

Distribution: 324 Saban. Moron, Bataan, October 16, 1969; 469 Panibatuhan, Moron, Bataan, May 5, 1970.

Genus ANADYOMENE Lamouroux, 1812

ANADYOMENE STELLATA (Fulfen) C. Agardh. Plate 3, fig. 15.

TAYLOR (1960) 125. pl. 7, fig. 2; pl. 3, fig. 2.

Plants dwarf, erect and solitary, with crowded leaves of fan-shaped expansion, short whorled lateral veins enclosing a cell layer lamina simulating a primitive leaf.

The plants usually grow luxuriantly in protected crevices of rock boulders but under exposed situations.

Distribution: 189 Balaytigue, Nasugbu, Batangas, November 27, 1968; 421 Botong, Taal, Batangas, January 3, 1970.

Order SIPHONALES

Family BRYOPSIDACEAE

Genus BRYOPSIS Lamouroux, 1809

BRYOPSIS PLUMOSA (Hudson) C. Agardh. Plate 4, fig: 16.

SEGAWA (1956) 14, fig. 65; TAYLOR (1960) 131, pl. 9, fig. 11.

Plants erect, growing up to 7 cm tall; light green, attached by rhizoids to stones and other small rocks or objects along exposed shores.

Distribution: 302 Botong, Taal, Batangas, attached to rocks in deeper portion of the littoral zone, July 25, 1969.

Genus BOERGESENIA Feldmann, 1938

BOERGESENIA FORBESII (Harvey) Feldmann. Plate 4, fig. 17.

SEGAWA (1956) 7, fig. 25; TRONO (1968) 157, pl. 17, fig. 7.

Plants solitary or in clumps, club-shaped, of various sizes, anchored by rhizoids at short cylindrical bases; thallus coenocytic growing up to 5 to 6 cm tall.

Distribution: 43a Bagong Silang, Calatagan, Batangas, near lighthouse, attached to corals, May 23, 1968; 102 Wawa, Nasug-

bu, Batangas, September 1, 1968; 196 Balaytigue, Nasugbu, Batangas, Noxember 27, 1968; 290 Moron, Bataan, June 12, 1968; 304 Botong, Taal, Batangas, July 25, 1969; 363 Kapayan Beach, Moron, Bataan, October 17, 1969.

Family CAULERPACEAE

Genus CAULERPA Lamouroux, 1809

CAULERPA PELTATA Lamouroux. Plate 4, fig. 18.

TAYLOR (1960) 155, pl. 17, fig. 2; pl. 18, fig. 1.

Plants small, growing usually in crevices of protected rocks; photosynthetic vertical branches pellate, generally 5 mm in diameter, borne on fine stalks and anchoring rhizoids; seldom encountered during collections and rarely growing luxuriantly.

Distribution: 268 Bagong Silang, Calatagan, Batangas, April 1969; 300 Botong, Taal, Batangas, July 25, 1969.

CAULERPA SERTULARIOIDES (Gmelin) Howe. Plate 4, fig. 19.

TAYLOR (1960) 144, pl. 13, figs. 1-3; TRONO (1968) 168, pl. 16, fig. 5.

Plants forming large colonies, stolons extensively branching in all directions; plant mass anchored firmly by stout branching rhizoids of vertical growth; photosynthetic branches composed of soft closely pinnate leaves growing to 6 cm tall, slightly upcurved at the rounded, conical or mucronate tips.

C. sertularioides is an edible species, but does not grow as much as *C. racemosa.*

Distribution: 53 Bagong Silang, Calatagan, Batangas, June 9, 1968; 280 Moron, Bataan, June 12, 1969; 457 Sabang, Moron, Bataan, May 4, 1970; 471 Panibatuhan, Moron, Bataan, May 5; 1970.

CAULERPA RACEMOSA (Forsskaal) J. Agardh. Plate 4, fig. 20.

SEGAWA (1956) 16, fig. 12; TAYLOR (1960) 151, pl. 17, figs. 6 & 11; pl. 18, figs. 2, 3, 5; TRONO (1968) 171, pl. 14, fig. 9.

Plants spreading in all directions branching stolons coarse; mature colonies very densely entangled, anchored by coarse, descending rhizoids attached firmly to substrate. The edible species grow luxuriantly in deep, open and sandy substrata. *C. racemosa* is the most commonly collected species of the genus *Caulerpa* with many varieties and forms depending on environmental conditions. It is the most common species sold in the market.

Caulerpacin [Doty & Santos (1966)] is perhaps an antibiotic substance from *Caulerpa* sometimes taken as food of some rock fishes which developed poison during some seasons of the year.

Distribution: 14 Bagong Silang, Calatagan, near lighthouse in shallow portions of littoral zone May 23, 1968; 191 Balaytigue, Nasugbu, Batangas, November 27, 1968; 230 Buaya Pt., Calatagan, Batangas, February 2, 1969; 270 Moron, Bataan, June 12; 1969, 409 Botong, Taal, Batangas, January 3, 1970; 450 Sabang, Moron, Bataan, May 4, 1970; 485 Panibatuhan, Moron, Bataan, May 5, 1970; 508 Kapayan Beach, Moron, Bataan, May 6, 1970.

CAULERPA SERRULATA (Forsskaal) J. Agardh. Plate 5, fig. 21.

DAWSON (1954) 393, fig. 10a; TAYLOR (1960) 145. pl. 14, fig. 15.

Plants stout stolons branching in all directions, anchored by strong rhizoids with erect photosynthetic branches; characteristic foliar branches serrated twisting and usually dichotomous towards tip. Not as palatable as *C. racemosa* and *C. sertularioides* perhaps due to sharp serrated margin of the foliar branches

Distribution: 127 Bagong Silang, Calatagan, Batangas, near lighthouse, in deeper portion of littoral zone, May 23, 1968; 190 Balaytigue, Nasugbu, Batangas, November 27, 1968; 279 Moron, Bataan, June 12, 1969; 301 Botong, Taal, Batangas, July 25, 1969; 449 Sabang, Moron, Bataan, May 4, 1970; 510 Kapayan Beach, Moron, Bataan, May 6, 1970.

Family CODIACEAE

Genus AVRAINVILEA Decaisne, 1842

AVRAINVILLEA ERECTA (Berkeley) A. and E. S. Gepp. Plate 5, fig. 22.

GILBERT & DOTY (1969) 123, figs 7-8, pl. 10, figs. 86 & 89.

Plants conspicuously fan-shaped, fronds growing on sandy-muddy and shallow bottom exposed on flats during low tides; stocked with stout, often cylindrical, massive rhizoids growing vertically downward, 2 to 3 times longer than upright photosynthetic fronds. The fan-shaped plants become subreniform, reaching up to 4.5 cm diameter depending on environmental variation.

Distribution: 499 Kapayan Beach, Moron, Bataan, May 6, 1970.

Genus UDOTEA Lamouroux, 1812

UDOTEA ORIENTALIS A. and E. S. Gepp. Plate 5, fig. 23.

SEGAWA (1956) 18, fig 89; GILBERT and DOTY (1969) 125, fig. 4.

Plants solitary, stipitate, with small holdfasts growing on shells, small rocks and sandy substratum; blades fan-shaped and

slightly calcified up to 2.5 cm in diameter, some having tendency to branch. Common in shallow water along open shores.

Distribution: 383 Nagbalayon, Moron, Bataan, October 17, 1969; 401 Panibatuhan, Moron, Bataan, October 18, 1969; 452 Sabang, Moron, Bataan, May 4, 1970.

Genus HALIMEDA Lamouroux, 1812

HALIMEDA OPUNTIA (Linnaeus) Lamouroux. Plate 5, fig. 24.

BARTON (1899-1900) 18, pl. 2, figs. 19-23, 25-27; SEGAWA (1956) 19, fig. 90; TAYLOR (1950) 80, pl. 39, fig. 1.

Plants whitish, green with crowded irregular branches originating from various points of inconspicuous stems; leaves rounded to reniform, generally trilobed, growing up to almost 10 mm in diameter; photosynthetic leafy segments very highly calcified, connected by flexible; uncalcified joints. Most common species seen and collected in shallow littoral zones exposed to waves.

Distribution: 111 Wawa, Nasugbu, Batangas, September 1, 1968; 169 Bagong Silang, Calatagan, Batangas, October 29, 1968; 221 Buaya Pt., Calatagan, Batangas, February 2, 1969.

HALIMEDA VELASQUEZII Taylor. Plate 5, fig. 25.

TAYLOR (1962) 175-177, figs. 8 and 11.

Plants small up to 6 to 7.5 cm tall; collected from crevices of rock boulders protected in deep narrow channels exposed to currents; compact segments generally 4.5 to 7 mm diameter, rounded to transversely oval and regularly calcified.

Still recognized as a good species after almost a decade of its publication in 1962 (letter received from Dr. Wm. R. Taylor, April 30, 1971).

Distribution: 193 Balaytigue, Nasugbu, Batangas. November 72, 1968; 379 Punong Pandil, Nagbalayon, Moron, Bataan; October 17, 1969.

HALIMEDA TUNA Lamouroux. Plate 6, fig. 26.

BARTON (1899-1900) 11, pl. 1, figs. 1-2, 42b, 5-6; TAYLOR (1960) 178, pl. 24, fig. 5.

Plants up to 12 cm tall, several branches of lateral expansion spread fanlike, very attractive when collected in its habitat; photosynthetic segments subcuneate and regularly calcified towards base, segments growing up to 20 cm in diameter, becoming transversely oval, smaller, and more rounded towards tip.

The species grow luxuriantly in sandy-muddy and deeper habitats in the littoral zone undisturbed by waves.

Distribution: 381 Nagbalayon, Moron, Bataan, October 17, 1969; 405 Panibatuhan, Moron, Bataan, October 18, 1969; 408 Botong, Taal, Batangas, January 3, 1970.

HALIMEDA MACROLOBA Decaisne. Plate 6, fig. 27.

BARTON (1899-1900) 24, pl. 3, figs. 33-34; SEGAWA (1956) 19, fig. 92.

Plants usually large, growing up to 18 cm tall; segments rounded and reniform, borne on short, stout stalks strongly anchored to sandy-muddy bottom. Broadly oval segments distinctly green and much calcified when mature. Confused with *Halimeda discoidea* Decaisne.

Distribution: 287 Moron, Bataan, June 12, 1969; 392 Panibatuhan, Moron, Bataan, October 18, 1969; 504 Kapayan Beach, Moron, Bataan, May 6, 1970.

Genus CODIUM Stackhouse, 1795

CODIUM TENUE Kuetzing. Plate 6, fig. 28.

SEGAWA (1956) 20, fig. 100.

Plants bushy, green, about 10 cm tall; at first irregularly branched, becoming fairly and regularly dichotomous above; thallus cylindrical with lower internodes up to 2.5 cm long, decreasing to 0.5 to 1.0 cm towards upper branches.

Distribution: 382 Nagbalayon, Moron, Bataan, October 17, 1969.

PHAEOPHYTA

Photosynthetic pigments are localized in plasids of chromatophores, and masked by a brown pigment, fucoxanthin. Plants called "Kelps" are always multicellular, filamentous and foliose to gigantic forms in cold waters, growing up to 67 feet tall.

There are three distinct life histories; namely, isogeneratæ and heterogeneratæ with an alternation of generation of haploid sexual plants and diploid asexual plants; the third, cyclosporæ with only diploid plants. Asexual zoospores and motile gametes are laterally biciliated of unequal length.

Key to the species of Phæophyta

1. Thallus flat, lower half adhering to substratum, free towards periphery .... *Pocockiella variegata*
   Thallus not flat, not adhering as above 2

2. Thallus at first attached, usually free on maturity 3
   Thallus always attached 4
3. Surface growth reticulate, sometimes spreading widely *Hydroclathrus clathratus*
   Surface growth smooth and lobed . . . . *Colpomenia sinuosa*
4. Thallus regularly fanlike 5
   Thalus never fanlike 7
5. Thallus up to 12 to 13 cm tall . . . . *Padina crassa*
   Thallus shorter than 12 cm 6
6. Thallus up to 5 cm tall . . . . *P. japonica*
   Thallus smaller, seldom 4 cm tall . . . . *P. minor*
7. Thallus always dichotomous 8
   Thallus never dichotomous 10
8. Thallus conspicuous branches regularly dichotomous, segments up to 0.8 cm wide . . . . *Dictyota dichotoma*
   Thallus not as conspicuous, branches irregularly dichotomous, segments 0.2 cm wide 9
9. Height up to 20 cm; dichotomous branches gradually tapering towards tips . . . . *D. cervicornis*
   Height up to 9 cm, dichotomous branches abruptly narrowed towards tips . . . . *D divaricata*
10. Thallus dark, bushy, irregular branches throughout. *Chnoospora implexa*
    Thallus not as dark, with several regular branches . . . 11
11. Primary branches numerous at base . . . . . *Hormophysa triquetra*
    Primary branches not as numerou, more of secondary branches . . 12
12. Leaves thin, usually with fine serrated margins, stalked spherical vesicles present 13
    Leaves thick with coarsely serrated margins, each with inconspicuous vesicles . . . . *Turbinaria ornata*
13. Foliar organs broad, lanceolate to ovate, 2 to 4 times as long as breath . . . . *Sargassum polyceratium*
    Foliar organs narrow, lanceolate, generally 3 to 4 times as long as breath . . . . *Sargassum* sp

Order DICTYOTALES

Family DICTYOTACEAE

Genus DICTYOTA Lamouroux, 1809

DICTYOTA DICHOTOMA (Hudson) Lamouroux. Plate 6, fig. 29.

SEGAWA (1956) 26, fig. 119; TAYLOR (1960) 218, pl. 31, fig 5

Plants bushy and erect, growing up to 15 cm tall; thallus coarse, generally 5 to 12 mm wide, exhibiting very conspicuous, regular dichotomy with forking 15 to 45° apart. The species cannot be confused since it is the largest and most attractive of the *Dictyota* species.

Distribution: 359 Kapayan Beach, Moron, Bataan, October 17, 1969; 453 Sabang, Moron, Bataan, May 1, 1970; 532 Botong, Taal, Batangas, May 16, 1970.

DICTYOTA CERVICORNIS Kuetzing. Plate 6, fig. 30.

TAYLOR (1960) 222, pl 31., fig. 2.

Plants bushy, erect when young, growing up to 20 cm tall, becoming entangled on maturity; branches irregularly dichotomous, slender in many specimens, becoming proliferous, gradually tapering and cervicorn towards top.

Very common in shallow water, growing on rocks, shells and sandy-muddy substrata.

Distribution: 162 Bagong Silang, Calatagan, Batangas, October 29, 1968; 358 Kapayan Beach, Nagbalayon, Moron, Bataan, October 17, 1969; 454 Sabang, Moron; Bataan, May 4, 1970; 472 Panibatuhan, Moron, Bataan, May 5, 1970; 533 Botong, Taal, Batangas, May 16, 1970.

DICTYOTA DIVARICATA Lamouroux. Plate 7, fig. 31.

TAYLOR (1960) 221, pl. 31, figs. 3 & 4.

Plants small, 5 to 9 cm tall with branches closely spreading, much entangled and regularly dichotomous, up to 120 cm wide; matured specimens with crowded segments usually subtended by fine rhizoids. Commonly collected in shallow water growing on shells, rocks and other strata.

Distribution: 249 Bagong Silang, Calatagan, Batangas, near lighthouse, in deeper portions of littoral zones, April 19, 1969.

Genus POCOCKIELLA Papenfuss, 1943

POCOCKIELLA VARIEGATA (Lamouroux) Papenfuss. Plate 7, fig. 32.

SEGAWA (1956) 29, fig. 132; TAYLOR (1960) 231, pl. 33. fig. 4.

Plants 2 to 8 cm tall; basally attached by rhizoids to rocks and boulders in deeper part of open littoral zones; thallus usually cleft, kidney-shaped to broadly orbicular, light to dark brown when matured. Common in intertidal rocks, growing luxuriantly in deeper habitats.

Distribution: 234 Buaya Pt., Calatagan, Batangas, on submerged rocks off the mangrove shoreline, February 2, 1969; 370 Nagbalayon, Moron, Bataan, October 19, 1969.

Genus PADINA Adamson, 1763

PADINA CRASSA Yamada. Plate 7, fig. 33.

SEGAWA (1956) 30, fig. 137.

Plants dull green, growth exceeding 12 cm high; matured specimens wide, fan-shaped, generally calcified thalli; attractive

due to their conspicuous concentric zones, very common and abundant in protected shallow shores, quite polluted when observed during low tide.

NOTE: See *P. australis* — blades conspicuously stipitate in some species.

Distribution: 16 Bagong Silang, Calatagan, Batangas, near lighthouse, growing on rock forming beds in middle portion of intertidal zone, May 23, 1968; 96 Wawa, Nasugbu, Batangas, September 1, 1968; 174 Balaytigue, Nasugbu, Batangas, November 27, 1968; 276 Moron, Bataan, June 12, 1969; 331 Sabang, Moron, Bataan, October 16, 1969; 527 Botong, Taal, Batangas; May 16, 1970.

PADINA JAPONICA Yamada. Plate 7, fig 34.

SEGAWA (1956) 30, fig. 138; TRONO (1968) 36.

Plants of regular size around 5 cm tall, usually stipitate; calcified blade broadly flabellate, with concentric zonations narrow and progressively widening toward margin.

Distribution: 17 Bagong Silang, Calatagan, Batangas, near lighthouse, growing in middle portion of zone, May 23, 1968; 96a and 97 Wawa, Nasugbu, Batangas, September 1, 1968; 216 Buaya Pt., Calatagan, Batangas, February 2, 1969; 308 Botong, Taal, Batangas, July 25, 1969; 332 Sabang, Moron, Bataan, October 16, 1969; 396 Panibatuhan, Moron, Bataan, October 18, 1969; 436 Sitio Saay, Limay, Bataan, January 24, 1970.

PADINA MINOR Yamada. Plate 7, fig. 35.

SEGAWA (1956) 30, fig. 136; TRONO (1968) 36, pl. 3, fig. 1 & 4.

Plants small, seldom 4 cm tall; blades thin and entire, arranged like petals, not calcified; regular zonations conspicuous and equidistant from base to margin.

Distribution: 85 Pulong Bato, Orion, Bataan, August 5, 1968; 308 Botong, Taal, Batangas, July 25, 1968.

Order PUNCTARIALES

Family PUNCTARIACEAE

Genus COLPOMENIA Derbes and Solier, 1856

COLPOMENIA SINUOSA (Roth) Derbes and Solier. Plate 7, fig. 36.

SEGAWA (1956) 137, fig. 168; TAYLOR (1960) 260, pl. fig. 1.

Plants light to rich yellow brown, generally solitary, clustered and sessile, attached by rhizoids, becoming much lobed to large irregular expansion up to 15 cm diameter; very common in sandy-muddy substratum. Solitary forms are usually collected closely attached to midrib remains of matured *Thalassia* grasses.

Distribution: 218 Buaya Pt., Calatagan, Batangas, February 2, 1969; 432, Limay, Bataan, January 24, 1970; 451 Sabang, Moron, Bataan, May 4, 1970; 520 Kapayan Beach, Moron, Bataan, May 6, 1970.

Genus HYDROCLATHRUS Bory, 1826

HYDROCLATHRUS CLATHRATUS (Bory) Howe. Plate 8, fig. 37.

SEGAWA (1956) 37, fig. 171; TAYLOR (1960) 260, pl. 36, fig. 1; GALUTIRA & VELASQUEZ (1963) 500, pl. 2, fig. 7; pl. 7, fig. 26.

Plants at first small, subspherical masses soon irregularly expanding into vast netted gowth of thalli which cover large areas in somewhat exposed collecting zones. Edible material collected during maturity before the thallus changes from light to dark brown.

Distribution: 15 Bagong Silang, Calatagan, Batangas, May 23, 1968; 218 Buaya Pt., Calatagan, Batangas, February 2, 1969; 443 Sabang, Moron, May 4, 1970; 476 Panibatuhan, Moron, Bataan, May 5, 1970; 597 Kapayan Beach, Moron, Bataan, May 6, 1970

Genus CHNOOSPORA J. Agardh, 1847

CHNOOSPORA IMPLEXA (Hering) J. Agardh. Plate 8, fig. 38.

SEGAWA (1956) 38, fig. 177.

Plants of moderate size, attached strongly by discoid discs, growing up to 10 to 15 cm tall; rigid (not adhering much on paper in drying); axis polychotomous, irregularly branching with unequal lightly compressed segments generally up to 15 mm long; expanded at base of branches, gradually tapering towards tip.

Growth luxuriant on rocks exposed to continuous waves.

Distribution: 517 Kapayan Beach, Moron, Bataan, May 6, 1970.

Order FUCALES

Family FUCACEAE

Genus HORMOPHYSA Kuetzing

HORMOPHYSA TRIQUETRA (C. Agardh) Kuetzing. Plate 8, fig. 39.

BOERGESEN (1937) 317; TAYLOR (1966) 357.

Plants very bushy, up to 4 dm tall; dark brown, firmly attached by very strong discs on shallow exposed rocks and boulders; several primary axis arising from base, stems tuberculate, branches tricostate; angular thallus beset with soft projections serving perhaps as foliar protections; vesicles visibly inflated along

branches; cryptostomata present in branches and foliar projections.

Distribution: 176 Balaytigue, Nasugbu, Batangas, November 27, 1568; 320 Sabang, Moron, Bataan, October 16, 1969.

Genus TURBINARIA Lamouroux, 1826

TURBINARIA ORNATA (Turner) J. Agardh. Plate 8, fig. 40.

SEGAWA (1956) 46, fig. 208; TRONO (1968) 37.

Plants up to 12 cm tall, usually thin, robust in some specimens, attached firmly to rocks by prominent rhizoids; branches rare, with rough leaves usually small, dilated and spiny at top, reproductive branches conspicuous, generally axillary and stout. Very common, but seldom abundant in collections.

Distribution: 30 Bagong Silang, Calatagan, Batangas, May 23, 1968; 201 Balaytigue, Nasugbu, Batangas, November 27, 1968; 220a Buaya Pt., Calatagan, Batangas; February 2, 1969; 347 Kapayan Beach, Moron, Bataan, October 17, 1969; 389 Panibatuhan, Moron, Bataan, October 18, 1969; 411 Botong, Taal, Batangas, January 3, 1970.

Genus SARGASSUM C. Agardh, 1820

SARGASSUM POLYCERATIUM Montagne. Plate 8, fig. 41.

TAYLOR (1960) 276, pl. 40, fig. 1; DAWES (1967) 57-58.

Plants firmly attached by a disc holdfast with usually smooth upright branches, 4 to 7 cm tall; foliar blades nearly sessile, serrate, broadly lanceolate-ovate, with rounded bases and tips, 1.5 to 3 cm long, 5 to 8 mm wide; stalked floats 3 to 5 mm diameter. Species examined sterile.

Distribution: 345 Sabang, Moron, Bataan, October 16, 1969; 388 Panibatuhan, Moron, Bataan, October 18, 1969.

SARGASSUM sp. Plate 9, fig. 42.

Plants attached by a disc holdfast; bushy with 3 to 6 vertical branches originating from base, lateral branches crowded towards tip; foliar blades mostly lanceolate, finely serrated, generally tapering towards base and tip, 2.5 to 7.5 mm wide; floats small and numeous at tip. Reproductive structures not apparent in some specimens studied.

Species determination in the genus *Sargassum* is difficult because a plant assumes several forms depending on maturity and environmental conditions. One specimen collected in the fruiting stage is about the most typical in appearance.

Distribution: 350 Kapayan Beach, Moron, Bataan, October 16, 1969, 387 Pambatuhan, Moron, Bataan, October 18, 1969; 435 Sitio Saay, Limay, Bataan, January 24, 1970.

RHODOPHYTA

Photosynthetic pigments are localized in one or more plastids or chromatophores and usually masked by red pigment phycoerythrin. Plants are mostly multicellular, seldom unicellular, represented by both filamentous and thalloid forms of different anatomical patterns; vegetative body organization branched or unbranched, compressed, cylindrical and foliaceous generally with no marked cell differentiation.

Asexual reproduction is by nonflagellated, naked monospores and tetraspores. Sexual reproduction is by union of nonflagellated spermatium and egg is a special sex organ called carpogonium. The fertilized egg undergoes meiosis to form haploid carpospores that germinate into sexual plants or divides directly into diploid carpospores which germinate as diploid plants.

Key to the species of Rhodophyta

1 Calcification entire or partial 2
Calcification absent 14
2 Calcification entire 3
Calcification partial 7
3 Thallus small, forming weak basal crust, segments very thin, regularly dichotomous . . . . *Jania pumila*
Thallus large, forming a strong basal crust, segments various, regularly and irregularly dichotomous 4
4. Branches subdichotomous and short, surface segments mamillous. *Lithothamnium erubescens*
Branches di- tri-, or tetrachotomous, segments variously developed . . . 5
5. Segments winged, undulate towards border . . . *Amphiroa foliacea*
Segments not winged, sometimes flat 6
6. Segments long, cylindrical and extensive, somewhat coarse, regularly dichotomous . . . . *A. fragilissima*
Segments short, usually stout, irregularly dichotomous, ultimate branchlets tapering or pointed . . . . *A hancockii*
7 Thallus foliaceous . . . . *Titanophora incrustans*
Thallus not foliaceous, dichotomous 8
8. Thallus soft 9
Thallus cartilaginous 12
9. Thallus small, at most 4 cm tall, closely dichotomous towards tip *Liagora cænomyce*
Thallus big, very much taller than 4 cm, regularly or variously dichotomous 10

10. Thallus about 12 cm tall, losely dichotomous .... *L. farinosa*
Thallus more than 12 cm tall, regularly and compactly dichotomous 11
11. Dichotomy closed compact towards tip ... . *L. ceranoides*
Dichotomy rather uniform throughout .... *L. valida*
12. Thallus attached by discoid holdfast, branches less bushy, loosely dichotomous .... *Galaxaura fastigiata*
Thallus attached by discoidal holdfast, branches very bushy, thicky dichotomous 13
13. Segments stout, 10 to 12 mm long, 1 to 2 mm diameter. *G. oblongata*
Segments thin, 5 to 10 mm long, 9 5 to 1.0 mm diameter . *G. cylindrica*
14. Thallus bladelike, sometimes expanded 15
Thallus not bladelike 20
15. Thallus thin, monostromatic . . .. *Porphyra crispata*
Thallus thick, polystromatic 16
16. Thallus much expanded and conspicuous .. .. *Callymenia sessiles*
Thallus slightly expanded and inconspicuous 17
17. Thallus regularly dichotomous 18
Thallus usually subdichotomous 19
18. Thallus at first simple, becoming gregarious, dichotomous with proliferations in younger segments .... *Grateloupia dichotoma*
Thallus dichotomous throughout, segments of equal length. *Callophyllis adhærens*
19. Thallus subdichotomous below becoming trichotomous at margin. *C. adnata*
Thallus gregarious and gelatinous, conspicuously subdichotomous at basal branches .... *Halymenia durvillæi*
20. Thallus terete, variously developed 21
Thallus irregularly flat, marginal branches abrupt and developed into spines .... *Meristotheca papulosa*
21. Thallus decumbent with indefinite growth 22
Thallus erect, mostly cartilaginous 23
22. Thallus tough and wiry, greenish to purplish, ultimate branches mostly recurved .... *Gelidiella acerosa*
Thallus reddish or bleached, branches numerous and entangled, ultimate branchlets cervicorn ... . *Hypnea cervicornis*
23. Thallus cartilaginous, rough with short smooth branches or spines. 24
Thallus not rough, branches di- tri- tetrachomus with spines . 27
24. Thallus broad about 8 mm, lateral spines solitary. *Eucheuma muricatum*
Thallus much narrower, branches crowded, with or without spines. 25
25. Branches irregular, beset with short sharp and conspicuous spines. *Acanthophora spicifera*
Branches irregular or regular, spines absent 26
26. Branchles lateral, alternate, short and inflated at apices. *Laurencia cartilaginea*
Branchlets crowded irregularly arranged, tuberculate .. *L. papillosa*
27. Thallus generally yellowish, branches di-, tri-, or tetrachotomous segments constricted at base . ... *Gracilaria salicornia*

Thallus greenish to purplish, branches alternate or dichotomous, segments not constricted at base 28

28. Thallus up to 20 cm tall usually without constriction, irregular branches tapering, cystocarps conspicuous .... *G. verrucosa*

Thallus short and stout, branches short .... *G. eucheumoides*

Order BANGIALES

Family BANGIACEAE

Genus PORPHYRA C. Agardh, 1824

PORPHYRA VARIEGATA Kjellman) Hus. Plate 9, fig. 43.

SEGAWA (1956) 55, fig. 248.

Plants conspicuous, attached by small holdfasts, membranous; blade soft, two cells in thickness, cells with stellate chromatophores; reproduction by monospores and carpospores. Collected only once.

Distribution: 89 Pulong Bato, Orion, Bataan, August 5, 1968.

Order NEMALIONALES

Family HELMINTHOCLADIACEAE

Genus LIAGORA Lamouroux, 1812

LIAGORA CAENOMYCE Decaisne. Plate 9, fig. 44.

SEGAWA (1956) 58, fig. 258.

Plants small, up to 4 cm tall; whitish, regularly dichotomous below, becoming purplish and closely dichotomous towards tip; segments highly calcified below, gradually diminishing above. Abundant on exposed rocks, seen during low tide.

Distribution: 50 Bagong Silang, Calatagan, Batangas, June 9, 1968; 184 Balaytigue, Nasugbu, Batangas, November 27, 1968; 424 Botong, Taal, Batangas, January 3, 1970.

LIAGORA FARINOSA Lamouroux. Plate 9, fig. 45.

TAYLOR (1960) 326, pl. 43, fig. 3; pl. 45, fig. 2; TRONO (1968) 44, pl. 8, fig. 3; DAWSON (1954) 415, fig. 26.

Plants up to 10 cm tall, attached on rocks; loosely dichotomous with branches entangled, pale, reddish masses; thallus slightly calcified readily adhering on paper upon drying. Growing along intertidal collecting zones.

Distribution: 183 Balaytigue, Nasugbu, Batangas, November 27, 1968; 475 Panibatuhan, Moron, Bataan, May 5, 1970.

LIAGORA CERANOIDES Lamouroux. Plate 9, fig. 46.

SEGAWA (1956) 58, fig. 259; TAYLOR (1960) 326-329, pl. 43, fig. 1; pl. 45, fig. 1.

Plants forming compact. soft, generally whitish tufts up to 10 cm tall; regularly dichotomous below, growth crowded towards tip, calcification moderate, surface especially below powdery on maturity. Attached to old corals, rocks and shells in shallow water.

Distribution: 535 Botong, Taal, Batangas, May 16, 1970.

LIAGORA VALIDA Harvey. Plate 9, fig. 47.

TAYLOR (1960) 327, pl. 43, fig. 2.

Plants small, up to 8 cm tall; branches dichotomous and somewhat crowded towards tip. Common in shallow and exposed rocks during low tides.

Distribution: 181a Balaytigue, Nasugbu, Batangas, November 27, 1968; 241 Bagong Silang, Calatagan, Batangas, April 19, 1969.

Genus GALAXAURA Lamouroux, 1812

GALAXAURA OBLONGATA (Ellis and Solander) Lamouroux. Plate 10, fig. 48.

CHOU (1945) 7-9, pl. 9, figs. 1-2; TAYLOR (1960) 341-342; TRONO (1968) 46-47, pl. 6, fig. 1.

Plants bushy, attached to rocks by prominent discs, 6 to 15 cm tall; branches regularly dichotomous easily bleached in sunlight; calcified segments 10 to 22 mm long, 1 to 2 mm diameter, joints between segments delicate, not calcified. Luxuriantly growing specimens bright red in deeper habitats, dull red in shallow situations.

Distribution: 144 Bagong Silang, Calatagan, Batangas, October 29, 1968, 181 Balaytigue, Nasugbu, Batangas, November 27, 1968; 447 Sabang, Moron, Bataan, October 16, 1969; 348 Kapayan Beach, Moron, Bataan, October 17, 1969; 380 Punong Pandil, Nagbalayon, Moron, Bataan, October 17, 1969; 398 Panibatuhan, Moron, Bataan, October 18, 1969; 410 Botong, Taal, Batangas, January 3, 1970.

GALAXAURA FASTIGIATA Decaisne. Plate 10, fig. 49.

SEGAWA (1956) 60, fig. 268; DAWSON (1954) 419, fig. 30b.

Plants bushy, attached by conspicuous disc; branches loosely dichotomous with segments as long as 6 to 10 mm, moderately calcified except at joints. Not common in collection.

Distribution: 422 Botong, Taal, Batangas, January 3, 1970.

GALAXAURA CYLINDRICA (Ellis and Solander) Lamouroux. Plate 10, fig 50.

CHOU (1945) 5-7, pl. 8, fig. 1; TAYLOR (1960) 341, pl. 44, fig. 1.

Plants densely bushy, attached by prominent discs, up to 10 cm tall; branches regularly dichotomous, slender, usually 1 or

Plants forming compact, soft, generally whitish tufts up to 10 cm tall; regularly dichotomous below, growth crowded towards tip, calcification moderate, surface especially below powdery on maturity. Attached to old corals, rocks and shells in shallow water.

Distribution: 535 Botong, Taal Batangas, May 16, 1970

LIAGORA VALIDA Harvey Plate 9, fig 47

TAYLOR (1960) 327, pl 43, fig 2.

Plants small, up to 8 cm tall; branches dichotomous and somewhat crowded towards tip Common in shallow and exposed rocks during low tides

Distribution: 181a Balaytigue, Nasugbu, Batangas, November 27, 1968; 241 Bagong Silang, Calatagan, Batangas, April 19, 1969.

Genus GALAXAURA Lamouroux, 1812

GALAXAURA OBLONGATA (Ellis and Solander) Lamouroux Plate 10, fig. 48.

CHOU (1945) 7-9, pl. 9, figs. 1-2; TAYLOR (1960) 341-342; TRONO (1968) 46-47, pl. 6, fig. 1.

Plants bushy, attached to rocks by prominent discs, 6 to 15 cm tall; branches regularly dichotomous easily bleached in sunlight; calcified segments 10 to 22 mm long, 1 to 2 mm diameter, joints between segments delicate, not calcified. Luxuriantly growing specimens bright red in deeper habitats, dull red in shallow situations.

Distribution: 144 Bagong Silang, Calatagan, Batangas, October 29, 1968, 181 Balaytigue, Nasugbu, Batangas, November 27, 1968; 447 Sabang, Moron, Bataan, October 16, 1969; 348 Kapayan Beach, Moron, Bataan, October 17, 1969; 380 Punong Pandil, Nagbalayon, Moron, Bataan, October 17, 1969; 398 Panibatuhan, Moron, Bataan, October 18, 1969; 410 Botong, Taal, Batangas, January 3, 1970.

GALAXAURA FASTIGIATA Decaisne. Plate 10, fig. 49.

SEGAWA (1956) 60, fig. 268, DAWSON (1954) 419, fig. 30b

Plants bushy, attached by conspicuous disc; branches loosely dichotomous with segments as long as 6 to 10 mm, moderately calcified except at joints. Not common in collection.

Distribution: 422 Botong, Taal, Batangas, January 3, 1970.

GALAXAURA CYLINDRICA (Ellis and Solander) Lamouroux. Plate 10, fig 50.

CHOU (1945) 5-7, pl. 8, fig. 1; TAYLOR (1960) 341, pl. 44, fig 1.

Plants densely bushy, attached by prominent discs, up to 10 cm tall; branches regularly dichotomous, slender, usually 1 or

less than a mm in diameter; proliferous due to heavy growth of dichotomous branches towards tip. Not as common as *G. oblongata.*

Distribution: 108 Wawa, Nasugbu, Batangas, September 1, 1968; 24 Bagong Silang, Calatagan, Batangas, May 23, 1970.

Order GELIDIALES
Family GELIDIACEAE
Genus GELIDIELLA Feldmann and Hamel, 1934

GELIDIELLA ACEROSA (Forrskaal) Feldmann and Hamel. Plate 10, fig. 51.

SEGAWA (1966) 65, fig. 289; TAYLOR (1960) 356, pl. 46, fig. 5; GALUTIRA & VELASQUEZ (1963) 502-503, pl. 3, figs. 9a-b; pl. 7, fig. 28

Plants greenish to dark purplish; decumbent or prostrate below, attached freely by haptera on exposed and submerged rocks during low tides; branches spreading profusely, tough, wiry, recurved subtended by short, limited branches 1 to 4 mm long, Sometimes abundant in collections. Edible and good source of agar.

Distribution: 113 Wawa, Nasugbu, Batangas, September 1, 1968; 170 Bagong Silang, Calatagan, Batangas, October 29, 1968; 286 Moron, Bataan, June 12, 1969; 307 Botong, Taal, Batangas, July 25, 1969.

Order CRYPTONEMIALES
Family CORALLINACEAE
Subfamily MELOBESIAE
Genus LITHOTHAMNIUM Philippi, 1937

LITHOTHAMNIUM ERUBESCENS Foslie.

WEBER and FOSLIE (1899-1900) 32, fig. 15; SEGAWA (1956) 70, fig. 308; TAYLOR (1960) 384; DAWSON (1954)) 426, figs. 38a-c.

Plants up to 4 cm tall, attached on rocks, very highly calcified, subdichotomous segments unequal, oftentimes slightly flattened below, terete and abruptly rounded, up to 1 to 1.2 mm average diameter. Collected once in shallow water, generally decumbent.

Distribution: 42 Bagong Silang, Calatagan, Batangas, May 23, 1968.

Subfamily CORALLINEAE
Genus AMPHIROA Lamouroux, 1812

AMPHIROA FOLIACEA Lamouroux. Plate 11, fig. 52.

WEBER and FOSLIE (1899-1900) 92-93, pl. 14, figs. 1-3, 7.

Plants firmly attached, branches trichotomous with adventitious growth at nodes, usually creeping horizontally, fertile segments

winged, generally flattened and ascending, undulating and cylindrical towards tip.

Distribution: 39 Bagong Silang, Calatagan, Batangas, May 23, 1968; 20 Balaytigue, Nasugbu, Batangas, November 27, 1968, 309 Botong, Taal, Batangas, July 25, 1969, 344 Sabang, Moron, Bataan, October 17, 1969; 521 Kapayan Beach, Moron, Bataan, May 6, 1970; 386 Punong Pandil, Moron, Bataan, October 17, 1969

AMPHIROA FRAGILISSIMA (Linnaeus) Lamouroux Plate 11, fig 53

WEBER and FOSLIE (1899 1900) 89-91, pl 14, fig 5, DAWSON (1954), 430, figs 1-2; TRONO (1968) 52-53

Plants cushion-shaped, brittle and highly calcified, forming extensive growth adpressed below on substrate, seldom 5 cm tall, branches regularly dichotomous, at times trichotomous adventitious branches very common, segments 8 to 15 times longer than width, tips prominently swelling. Very common in exposed and shallow littoral zones during low tides

Distribution: 139a Limay, Bataan, October 1, 1968, 288 Moron, Bataan, June 12, 1969; 299 Botong, Taal, Batangas, July 25 1969, 437 Sitio Saay, Limay, Bataan, January 24, 1970

AMPHIROA HANCOCKII Taylor. Plate 11, fig 54

TAYLOR (1960) 406, pl. 47, figs 6-8

Plants arising from inconspicuous base, growth up to 8 cm tall; branches stout, irregularly di-, to tetrachotomous, with numerous adventitious branches; primary branches flattened, somewhat radially arranged; segments smooth, usually rounded; adventitious growth flat, straight, or arcuate; terminal branches tapering into segments 5 to 8 mm long. Not common in collection.

Distribution: 343a Sabang, Moron, Bataan, October 16, 1969

Genus JANIA Lamouroux, 1812

JANIA PUMILA Lamouroux. Plate 11, fig 55

TAYLOR (1960) 414-415, pl 49, fig 5

Plants very small, up to 5 to 8 mm tall, decumbent, forming a colony 0.5 to 1.5 cm diameter; fine branches short and dichotomous; stout segments subcylindrical. Occasionally in colonies on old *Thalassia* leaves in protected collecting zones.

Distribution: 209b Balaytigue, Nasugbu, Batangas, November 27, 1968

Family GRATELOUPIACEAE

Genus HALYMENIA C. Agardh, 1817

HALYMENIA DURVILLAEI Bory. Plate 12, fig 56.

GALUTIRA and VELASQUEZ (1963) 504, pl. 5, fig. 29.

Plants bushy, gelatinous, arising from a basal disc; brilliant-red, slightly purplish in deep habitat; branches originating from base in 4 to 6 major divisions, decreasing progressively into smaller numerous branchlets towards tip, forming very attractive bushy habit

The alga grows luxuriantly in deep water, but seldom abundant Eaten raw after rinsing in hot water. It is a good source of agar.

Distribution 179 Balaytigue, Nasugbu, Batangas, November 27, 1968; 295 Botong, Taal, Bantagas, July 25, 1969; 400 Panibatuhan Moron, Bataan, October 18, 1969; 416 Botong, Taal, Batangas, January 3, 1970, 458 Sabang, Moron, Bataan, May 4, 1970; 514 Kapayan Beach, Moron, Bataan, May 6, 1970.

Genus GRATELOUBIA C. Agardh, 1822

GRATELOUPIA DICHOTOMA C. Agardh.

TAYLOR (1960) 424-425.

Plants gregarious, arising from conspicuous discs, 3 5 to 8 cm tall; blades simple, strap-shaped; dichotomously or irregularly dividing into flat segments with marginal proliferations; terminal segments often arcuate. Not commonly collected.

Distribution: 66 Bagong Silang, Calatagan, Batangas, June 9, 1968

Family KALLYMENACEAE

Genus CALLOPHYLLIS Kuetzing, 1843

CALLOPHYLLIS ADHAERENS Yamada Plate 12, fig 57.

SEGAWA (1956) 81, fig 380.

Plants dark red, attached by conspicuous discs, size up to 5 to 10 cm tall; flat, regularly dichotomous, thallus generally 2.5 cm long, 3 to 6 cm wide with forked ultimate branches. Quite commonly attached on rocks in open habitat.

Distribution: 419 Botong, Taal, Batangas, January 3, 1970.

CALLOPHYLLIS ADNATA Okamura Plate 12, fig. 58.

Plants small and gregarious, attached by discs usually on rocks in deeper habitats; thallus flat, dichotomously branched, ultimate branches with short, di- to trichotomous segments. Rare in collections.

Distribution: 395 Panibatuhan, Moron, Bataan, October 18, 1969.

Genus KALLYMENIA J. Agardh, 1842

KALLYMENIA SESSILIS Okamura. Plate 12, fig. 59.

SEGAWA (1956) 82, fig. 385

Plants attached by discs, with smooth expanded blades, without conspicuous veins; thallus rarely branched, sparsely perfor-

ated and sometimes torn at maturity. Collection very rare in open water.

Distribution: 360 Kapayan Beach, Moron, Bataan, October 17, 1969.

Order GIGARTINALES

Family NEMASTOMATACEAE

Genus TITANOPHORA (J. Agardh) Feldmann, 1942

TITANOPHORA INCRUSTANS (J. Ag.) Boergesen. Plate 13, fig. 60

TAYLOR (1960) 437-438.

Plants red and foliaceous, thalli up to 10 to 15 cm tall, becoming greenish with surface roughening with age; simple primary axis with stalked pinnate branching, gradually becoming smaller towards the tip.

Distribution: 185 Balaytigue, Nasugbu, Batangas, November 27, 1968; 399 Panibatuhan, Moron, Bataan, October 18, 1969.

Family GRACILARIACEAE

Genus GRACILARIA Greville, 1830

GRACILARIA VERRUCOSA (Hudson) Papenfuss. Plate 13, fig. 61

SEGAWA (1956) 89, fig. 417; TAYLOR (1960) 441, pl. 56, fig. 2; GALUTIRA and VELASQUEZ (1963) 507-508, pl. 4, fig. 13; pl. 8, fig 33

Plants bushy, attached by disclike bases, texture firm-fleshy; purple, slightly greenish growing up to 21 cm tall, branches 1 to 2.5 mm diameter, repeatedly dividing, sometimes dichotomous, with lateral proliferations. Collection common in shallow littoral zones. Cylindrical thalli are usually dotted irregularly with cystocarps.

Distribution: 2 Bagong Silang, Calatagan, Batangas, May 23, 1968; 110 Wawa, Nasugbu, Batangas, September 1, 1968; 339 Sabang, Moron, Bataan, October 16, 1969.

GRACILARIA SALICORNIA (C. Agardh) Dawson. Plate 13, fig. 62

DAWSON (1954) 4, fig. 3; GALUTIRA and VELASQUEZ (1963) 506-507, pl. 8, figs. 32a-b.

Plants usually in cæspitose clumps, attached by prominent discs up to 12 cm tall; segments of branches cylindrical, di- or trichotomous, sometimes tetrachotomous; segments deeply articulated at bases, up to 25 mm long and 4.5 mm diameter. Basal portion of segments tapering with smaller diameter at distal ends.

Very common in collection, sometimes exposed during low tides.

Distribution: 19 Bagong Silang, Calatagan, Batangas, May 23, 1968; 92 Sitio Saay, Limay, Bataan, April 5, 1968; 105 Wawa,

Nasugbu, Batangas, September 1, 1968; 305 Botong, Taal, Batangas, July 25, 1969.

GRACILARIA EUCHEUMOIDES Harvey. Plate 13, fig. 63.

DAWSON (1954) 438, fig. 48e; TRONO (1968) 63-64, pl. 6, fig. 8.

Plants flattened, variable, at most 8 mm wide; irregularly branched, creeping on rocks and hard corals, attached here and there by haptera; margin of thallus dentate or with sharp tooth-like projections. Common in collection from rocks exposed to wave action. Edible species

Distribution: 149 Bagong Silang, Calatagan, Batangas, October 29, 1968; 233 Buaya Pt., Calatagan, Batangas, February 2, 1969.

Family SOLIERACEAE

Genus EUCHEUMA J. Agardh, 1847

EUCHEUMA MURICATUM (Gmelin) Weber van Bosse. Plate 13, fig. 64.

GALUTIRA and VELASQUEZ (1963) 505, pl. 4, fig. 11; pl. 8, fig. 30.

Plants large, attached by a stout holdfast; texture cartilaginous; few branches terete and irregularly bilateral; matured branches abundantly papilous, young ones smooth; cystocarps readily visible, scattered in the thallus of many specimens.

Edible species. NOTE: *E. spinosum* and *E. cottonii*, both cultured in the Philippines, are of very high industrial value as sources of carrageenan.

Distribution: 289 Moron, Bataan, June 12, 1969.

Genus MERISTOTHECA J. Agardh, 1872

MERISTOTHECA PAPULOSA (Montagne) S. Agardh. Plate 14, fig. 65.

SEGAWA (1956) 85, fig. 401.

Plants pale red, attached by prominent discs, thallus irregular, usually up to 15 to 30 mm wide; lateral branches abruptly small, developing into spines. End of thallus usually sharp and forked.

Two separate specimens washed ashore by waves towards the shallow littoral zone were collected. Must have come from much deeper habitat.

Distribution: 90 Sitio Saay, Limay, Bataan, August 5, 1968.

Family HYPNEACEAE

Genus HYPNEA Lamouroux, 1813

HYPNEA CERVICORNIS J. Agardh. Plate 14, fig. 66.

TAYLOR (1960) 466, pl. 73, fig. 2; DAWSON (1954) 437-438, fig. 46B.

Plants grow as entangled tufts over a wide area, somewhat fragile, pale reddish or white in color; chief axis indefinite as much as 10 to 25 cm long; lower branches decumbent, those above conspicuously divaricate, subdichotomous, alternate and

cervicorn; ultimate branches tapering towards tip. Specimens exposed during lowest tides easily bleached in sunlight. Edible species.

Distribution: 32 Bagong Silang, Calatagan, Batangas, May 23, 1968; 180 Wawa, Nasugbu, Batangas, September 1, 1968; 180a Balaytigue, Nasugbu, Batangas, November 27, 1968; 340 Sabang, Moron, Bataan, October 16, 1969; 491 Panibatuhan, Moron, Bataan, May 6, 1970.

Order CERAMIALES

Family RHODOMELACEAE

Genus ACANTHOPHORA Lamouroux, 1813

ACANTHOPHORA SPICIFERA (Vahl) Boergesen. Plate 14, fig. 67.

TAYLOR (1960) 620-621, pl. 71, fig. 31; pl. 72, figs. 1-2; GALUTIRA and VELASQUEZ (1963) 510, pl. 9, figs. 37a-b.

Plants erect, dark and transparent, up to 20 cm tall, becoming bushy in favorable habitats, regular branches usually beset with short determinate, marked spines; main axes 2 to 4 mm diameter.

Very common in shallow water, observed abundant and more transparent in deeper habitat. The plant is edible and a very good source of agar.

Distribution: 107 Wawa, Nasugbu, Batangas, September 1, 1968.

Genus LAURENCIA Lamouroux, 1813

LAURENCIA CARTILAGINEA Yamada. Plate 14, fig. 68.

YAMADA (1931) 230-231, pl. 19, fig. a.

Plants transparent up to 16 cm tall; simple and secondary branches usually round, opposite pinnate, ultimate branches becoming shorter, tuberculous or wartlike, inflated at apices. Readily adhering to paper.

The species is edible and eaten raw after rinsing in hot water. Good source of agar.

Distribution: 178 Balaytigue, Nasugbu, Batangas, November 27, 1968; 460 Panibatuhan, Moron, Bataan, May 5, 1970.

LAURENCIA PAPILLOSA (Forsskaal) Greville. Plate 14, fig. 69.

TAYLOR (1960) 623-624, pl. 74, fig. 2; YAMADA (1931) 190-191, pl. 1, figs. a-b.

Plants densely clustered up to 12 cm tall, usually dark-purplish, subcartilaginous, not adherent to paper; primary axes alternately branched, branchlets becoming short towards tip, crowded and somewhat clavate-truncate.

The plant is less papillose in shallow water. This edible species is much taller and luxuriant in deeper habitat.

Distribution: 18 and 146 Bagong Silang, Calatagan, Batangas, May 23 and October 29, 1968, respectively

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GLOSSARY

Adpressed — To press close or lay flat (against).

Adventitious — Out of the usual place; arising sporadically.

Algin, alginic acid — an organic acid which occurs in fair quantities in many seaweeds, especially in the brown algæ having the composition of 42-per cent carbon, 4.5-per cent hydrogen, and 53.4-per cent oxygen.

Alginates — Salts of alginic acid.

Alternation of generation — The regular succession of sexual and asexual phases in the life history of an organism.

Annotated — To furnish with notes, usually critical or explanatory; to make notes about or upon.

Antibiotics — A chemical agent or substance produced by an organism which inhibits the growth of another organism(s).

Artificial classification — A system of classification based on one or few characters of a plant.

Asexual — No sexual gametes involved in reproduction.

Axillary — Situated in or growing from an axil.

Benthic — Attached form in a substrate of a given aquatic habitat

Bilateral — On both sides.

Blade — Thin expansion, usually flattened portion of the thallus.

Bleaching — Process of whitening or making white or lighter color

Brackish — Moderately salty.

Cæspitose — Hairlike or growing in tufts.

Calcified — Impregnated with calcareous matter like insoluble lime salts in a tissue or other material.

Carpogonium — The female sex organ of Rhodophyta, usually terminal on a branch, sometimes a metamorphosed cell which develops a protrusion.

Carpospore — A haploid or diploid spore produced either directly from the carpogonium after fertilization of the egg or indirectly at the completion of a filamentous development following fertilization.

Carrageenan — A product from red algæ or a cell wall polysaccharide complex used to stabilize food and culinaries, textile, pharmaceutical, leather and brewing industries.

Cartilaginous — Hard or tough, generally transparent.

Cervicorn — Branching like a deer horn.

Chromatophore — A color-carrying body within a cell protoplast.

Clavate — Club-shaped, thickened toward the apex.

Clump — A cluster or group; bunch.

Cœnocytic — A cell or thallus unit containing many nuclei; multi-nucleate.

Cuneate — Wedge-shaped.

Cushion — Soft like a pillow or pad.

Crevice — A narrow opening resulting from a split or crack; a fissure.

Cryptostomata — Sunken cavities containing hairs as in the leafy organs of *Sargassum* in the brown algæ.

Decumbent — Reclining with an ascending summit.

Dentate — Toothed especially directed forward.

Dichotomy — Branching in a forked fashion to form two equal segments.

Diploid — A plant or cell having double or unreduced number of chromosomes; usually a sporophyte generation.

Discoid — In the form of a disc.

Distichous — Arranged in two vertical rows along opposite sides of a branch.

Distromatic — Consisting of two layers of cells in thickness.

Divaricate — To part into two branches; to fork.

Entangled — Interwoven; twisted.

Flagellated — Provided with flagellum(a) for locomotion.

Foliaceous — Leafy or bladelike.

Forked — Separating in two divisions; more or less apart.

Fucoxanthin — The golden-brown pigment that mask the chlorophyll contained in considerable amount in brown algæ.

Fragile — Easily broken; brittle.

Gregarious — Habitually in flocks or groups.

Habit — The general appearance of a plant.

Habitat — The kind of locality in which a plant grows; "residence" of a plant.

Haploid — A plant or cell which has one-half or reduced number of chromosomes; usually a gametophyte generation.

Haptera — A rootlike holdfast consisting of the branched basal portion of an algal thallus.

Hemispherical — Resembling half a sphere in form

Holdfast — The disclike attachment of algæ.

Intertidal — The coastal zone which lies within the upper level of high tide and the lowest level of low tide; roughly the zone which is alternately covered and uncovered by tidal action.

Intestiniform — Like an intestine in form

Kidney-shaped — Shaped like a bean seed.

Laminarin — A polysaccharide of carbohydrate found in most brown algæ

Lithophilic — Saxicolous or living on rock

Littoral zone — The marine area characterized by forms of life found near the shore, generally the intertidal zone.

Mammillous — Having nipplelike or rounded projections

Membranous — Thin and flat like a membrane.

Monospores — Spores borne singly within a vegetative or an unmodified cell (sometimes slightly enlarged) as in some red algæ

Nonflagellated — Not provided with flagellum(a).

Obconical — Conical cells but attached at the narrow end.

Peltate — Shaped like a circular shield

Perforation — Pierced through or having translucent dots which appear like little holes

Pigment — Coloring matter in plant body.

Phycocyanin — Blue pigment in the protoplast of Cyanophyceæ and chromatophore of Rhodophyceæ.

Phycoerythrin — The red pigment in Rhodophyceæ.

Polluted — Presence of foreign materials in water particularly that which interferes with its use.

Polychotomous — Dividing into many parts, branches or classes; dividing regularly and repeatedly into such division

Polysiphonous — Provided with many pericentral cells

Polystromatic — Consisting of 3 or more layers of cells.

Prostrate — Lying flat.

Profusely — Abundant, exceedingly or excessively generous.

Reproductive — That which multiplies or tends to increase the number of an organism.

Rhizoid — A unicellular or uniseriate rootlike filament serving as attachment.

Scandent — Climbing in whatever manner.

Seaweed — Marine plants particularly algæ.

Segment — The portion or division of a thallus between points of branching or specifically in articulated corralines, the calcified portion (intergeniculum) between articulations

Serrated — Sawlike or having marginal teeth

Sessile — Attached without a stalk.

Sexual — That which involves the sexes or gametes.

Subdichotomous — An inferior division in pairs; a subdivision

Subsequent — Succeeding, that which follows after in time or in position

Substratum — The underlying structure or base where an organism attaches and grows

Subspherical — Almost spherical

Solitary — Consisting of only one, each separate by itself.

Stellate — Star-shaped, usually axial and radiate as applied

Stipitate — Stemlike appearance in many marine benthic algæ

Stolon — A runner or any basal branch which is disposed to root.

Symmetrical — Can be divided into similar halves

Terete — Circular in transverse section

Thallus — A plant body not differentiated into true roots, stems and leaves; the entire plant body of an alga.

Tricostate — Having three ribs.

Trilobed — Divided into three lobes

Tuberculate — Warty or verrucose

Tufts — Hairs branched from the base upward

Undulate — Bending in gradual curves like waves

Vegetative — Having the power of growing as the parent plant

Vesicle — Saclike; an utricle or bladderlike swollen portion of a thallus.

Zonation — Arrangement or distribution of zone

Zoospore — An animal like spore usually formed in vegetative cell provided with flagellum(a) and eyespot capable of producing new plant independently.

Zygote — A diploid cell resulting from a union of sex cells or gametes; a fertilized egg.

ILLUSTRATIONS

PLATE 1

Fig 1. *Ulva lactuca* Linnæus. × 2/3.
2 *Enteromorpha intestinalis* (Linnæus) Link. × 2/3.
3. *Enteromorpha clathrata* (Roth) J. Agardh. × 2/3.
4 *Chætomorpha crassa* (C. Agardh) Kuetzing. × 2/3

PLATE 2

Fig 5 *Chætomorpha gracilis* Kuetzing. × 2/3
6. *Neomeris annulata* Dickie. × 2/3.
7. *Halicoryne wrightii* Harvey. × 2/3.
8. *Acetabularia calyculus* Quoy and Gaimard. × 2/3
9 *Acetabularia major* Mertens. × 2/3.

PLATE 3

Fig 10. *Valonia ægagropila* C. Agardh. × 2/3.
11. *Dictyosphæria cavernosa* (Forsskaal) Bœrgesen. × 2/3
12. *Dictyosphæria vanbossæ* Bœrgesen. × 7.
13. *Microdictyon agardhianum* Decaisne. × 7.
14. *Chlorodesmis comosa* Harvey and Bailey. × 2/3.
15. *Anadyomene stellata* (Wulfen) C. Agardh. × 1/2.

PLATE 4

Fig. 16. *Bryopsis plumosa* (Hudson) C. Agardh. × 2/3.
17. *Bœrgesenia forbesii* (Harvey) Feldmann. × 2/3.
18. *Caulerpa peltata* Lamouroux. × 2/3.
19. *Caulerpa sertularioides* (Gmelin) Howe × 1/2.
20. *Caulerpa racemosa* (Forsskaal) J. Agardh. × 1/2.

PLATE 5

21. *Caulerpa serrulata* (Forsskaal) J. Agardh. × 1/2.
22. *Avrainvillea erecta* (Berkeley) A. and E. S. Gepp. × 2/3.
23. *Udotea orientalis* A. and E. S. Gepp. × 1.
24. *Halimeda opuntia* (Linnæus) Lamouroux. × 2/3.
25. *Halimeda velasquezii* Taylor. × 2/3.

PLATE 6

Fig. 26. *Halimeda tuna* Lamouroux. × 1/2.
27. *Halimeda macroloba* Decaisne. × 1/2
28. *Codium tenue* Kuetzing. × 2/3.
29. *Dictyota dichotoma* (Hudson) Lamouroux × 2/3.
30. *Dictyota cervicornis* Kuetzing. × 2/3.

PLATE 7

31 *Dictyota divaricata* Lamouroux. × 2/3.
32. *Pocockiella variegata* (Lamouroux) Papenfuss. × 2/3.
33. *Padina crassa* Yamada. × 1/2.
34. *Padina japonica* Yamada. × 2/3.
35. *Padina minor* Yamada. × 2/3.
36. *Colpomenia sinuosa* (Roth) Derbes and Solier. × 2/3.

PLATE 8

FIG. 37. *Hydroclathrus clathratus* (Bory) Howe. × 2/3.
38. *Chnoospora implexa* (Hering) J. Agardh. × 2/3.
39. *Hormophysa triquetra* (C. Agardh) Kuetzing. × 1/8
40. *Turbinaria ornata* J. Agardh. × 2/3.
41. *Sargassum polyceratium* Montagne. × 1/8.

PLATE 9

FIG. 42. *Sargassum* sp. × 1/8.
43. *Porphyra variegata* (Kjellman) Hus. × 2/3.
44. *Liagora cænomyce* Decaisne. × 2/3.
45. *Liagora farinosa* Lamouroux. × 2/3.
46. *Liagora ceranoides* Lamouroux. × 2/3

PLATE 10

FIG. 47. *Liagora valida* Harvey. × 2/3.
48. *Galaxaura oblongata* (Ellis and Solander) Lamouroux. × 2/3
49. *Galaxaura fastigiata* Decaisne. × 2/3.
50. *Galaxaura cylindrica* (Ellis and Solander) Lamouroux. × 2/3.
51. *Gelidiella acerosa* (Forsskaal) Feldmann and Hamel. × 2/3

PLATE 11

FIG. 52. *Amphiroa foliacea* Lamouroux. × 2/3.
53. *Amphiroa fragilissima* (Linnæus) Lamouroux. × 2/3.
54. *Amphiroa hancockii* Taylor. × 2/3.
55. *Jania pumila* Lamouroux. × 2/3.

PLATE 12

FIG. 56. *Halymenia durvillæi* Bory. × 1/3.
57. *Callophyllis adhærens* Bory. × 2/3.
58. *Callophyllis adnata* Okamura. × 2/3.
59. *Kallymenia sessilis* Okamura. × 2/3.

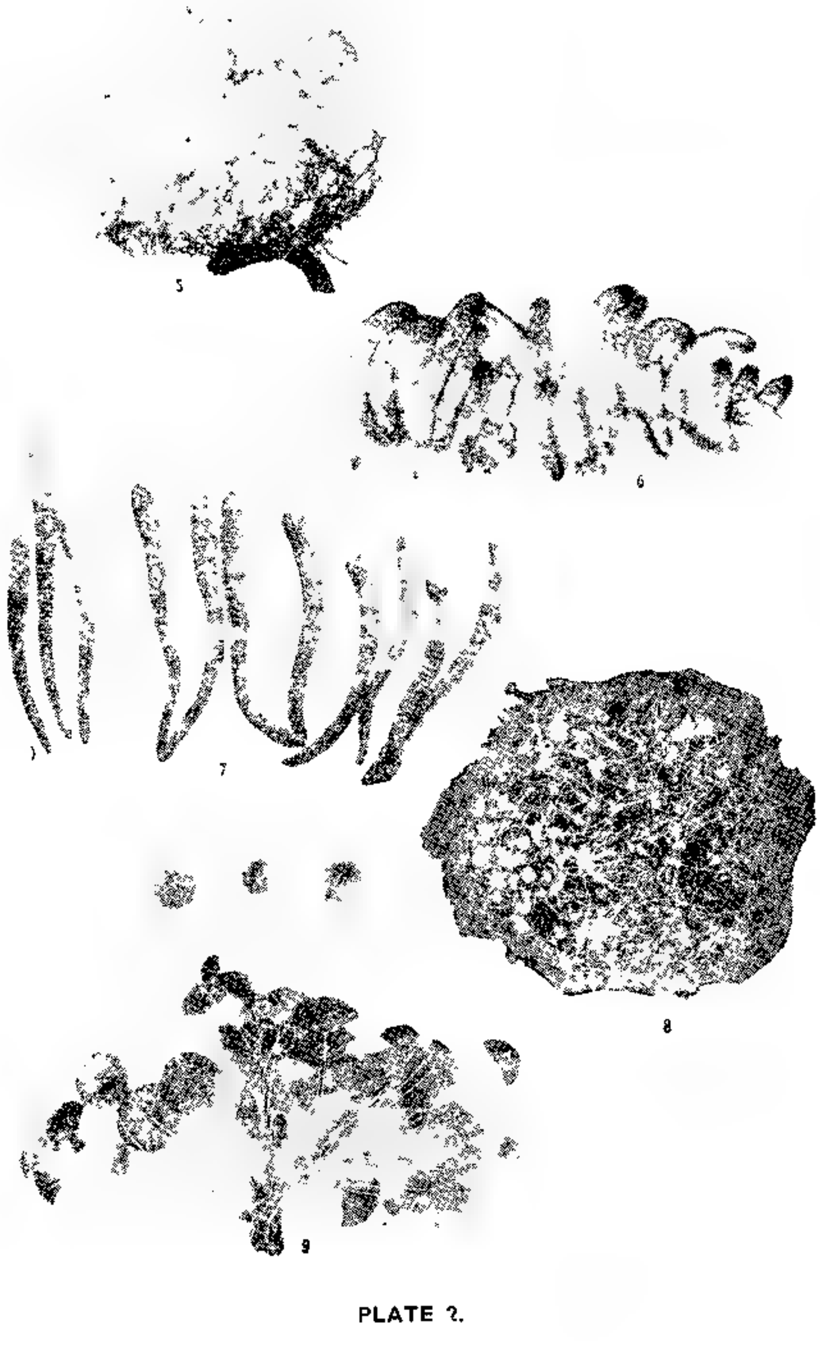
PLATE 13

FIG. 60. *Titanophora pulchra* Dawson. × 2/3.
61. *Gracilaria verrucosa* (Hudson) Papenfuss. × 1/2.
62. *Gracilaria salicornia* (C. Agardh) Dawnson. × 1/2.
63. *Gracilaria eucheumoides* Harvey. × 1/2.
64. *Eucheuma muricatum* (Gmelin) Weber van Bosse. × 1/2

PLATE 14

FIG. 65. *Meristotheca* sp. × 2/3.
66. *Hypnea cervicornis* J. Agardh. × 2/3.
67. *Acanthophora spicifera* (Vahl) Bœrgesen. × 2/3.
68. *Laurencia cartilaginea* Yamada. × 1/2.
69. *Laurencia papillosa* (Forsskaal) Greville. × 2/3.

PLATE 1.



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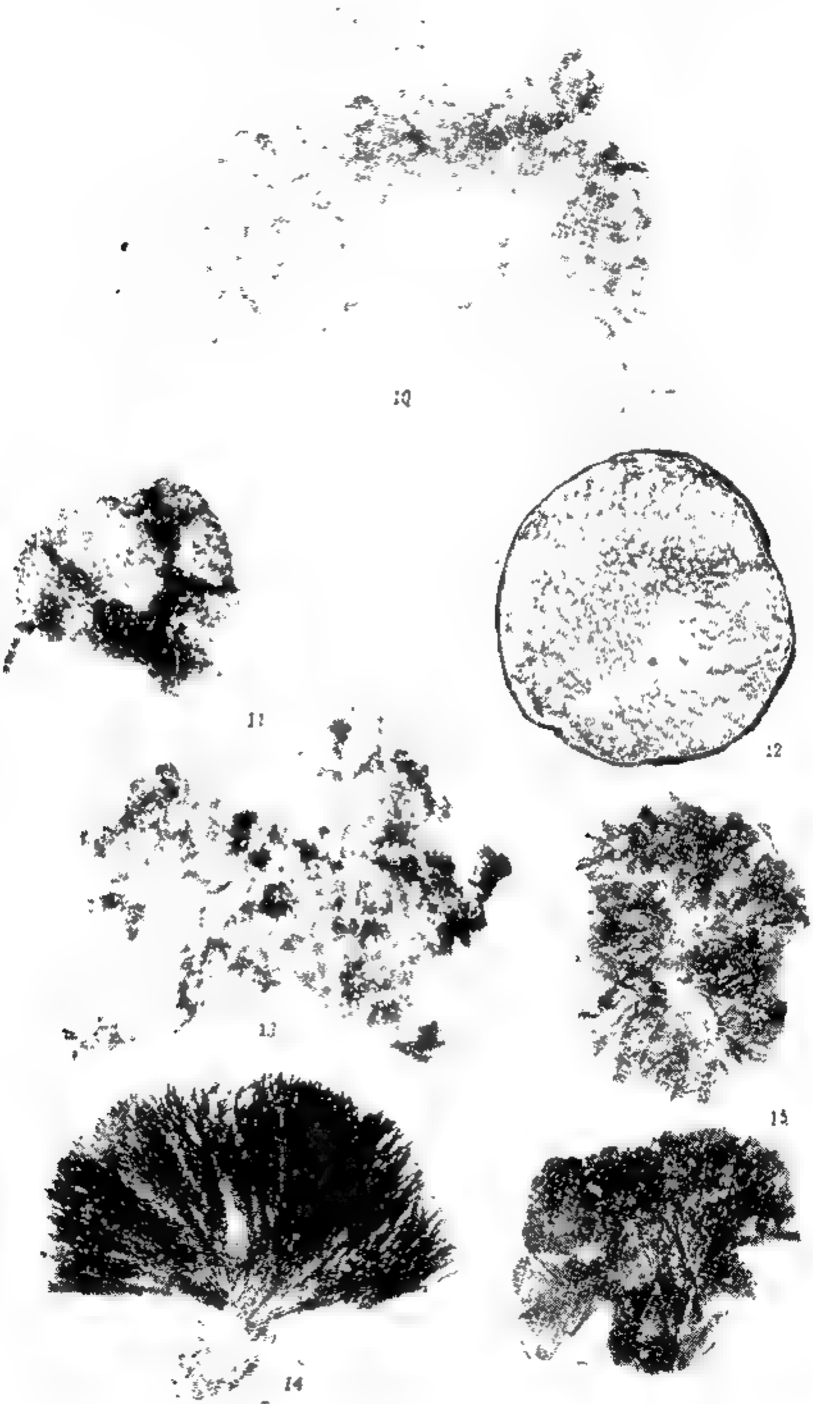

PLATE 3.

PLATE 4.

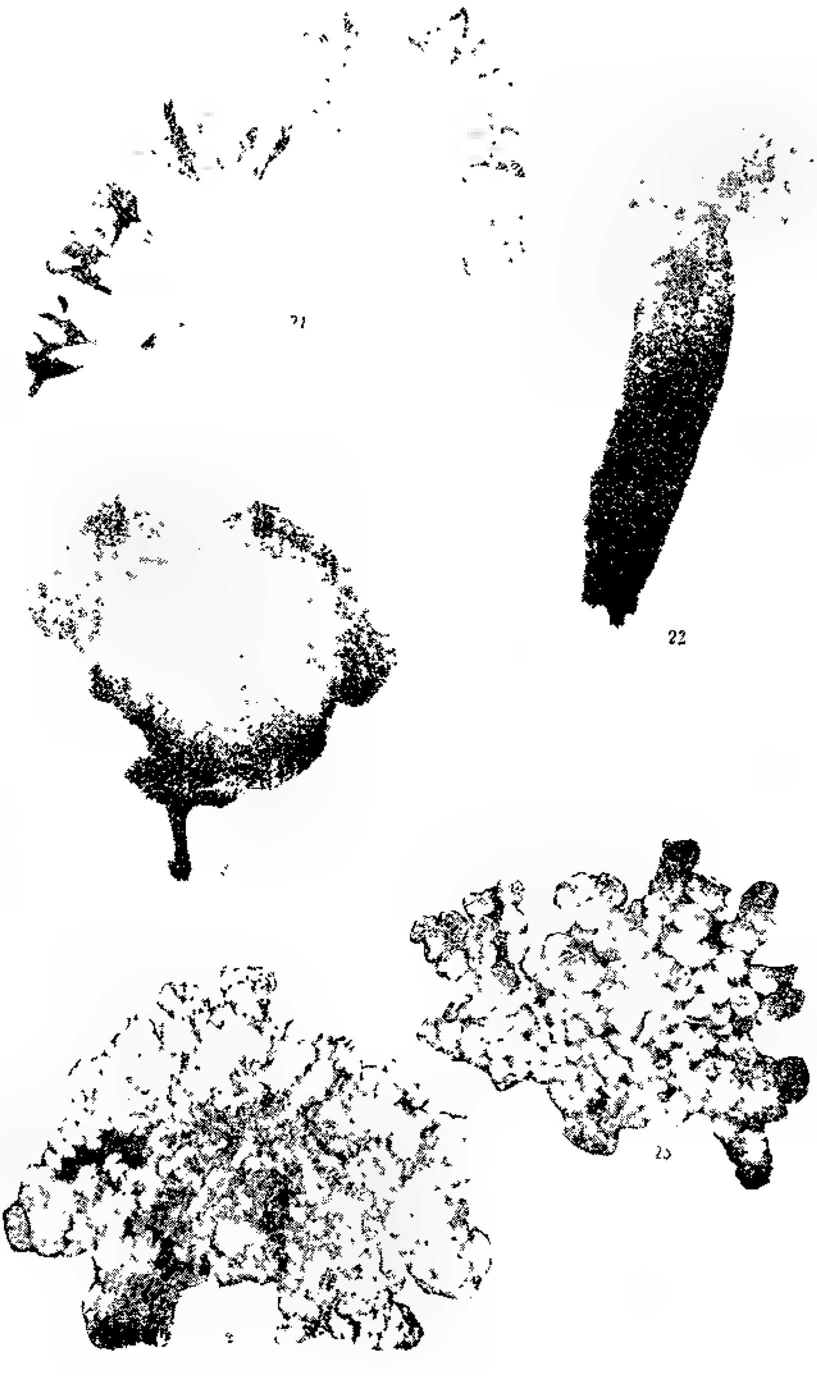

PLATE 5.

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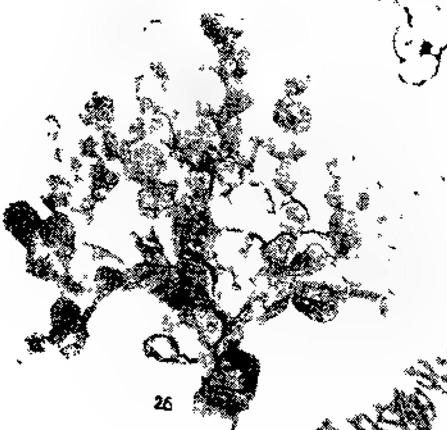

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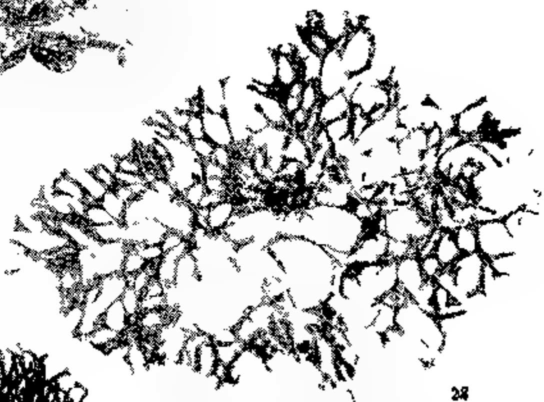

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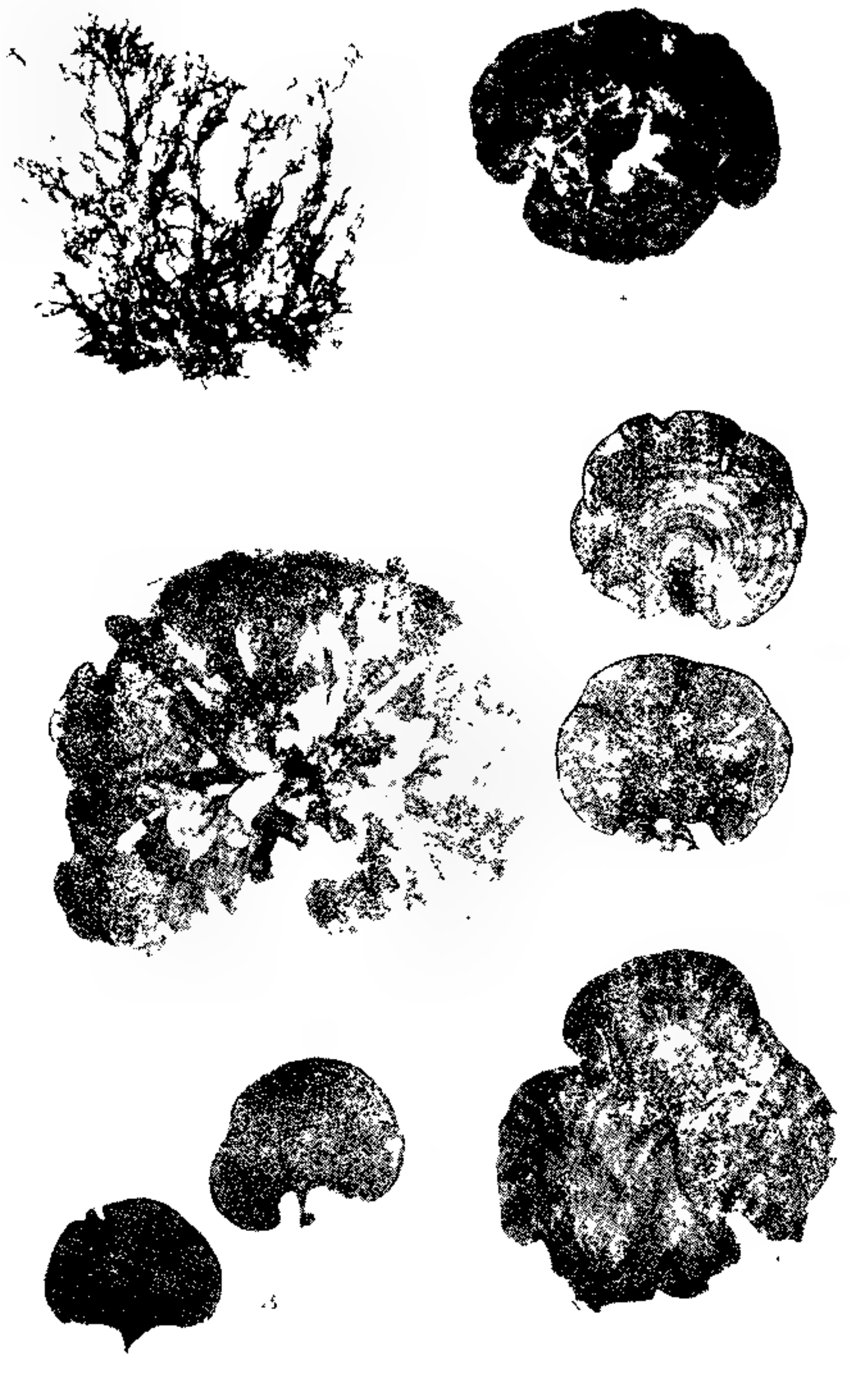

PLATE 7.

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PLATE 8.

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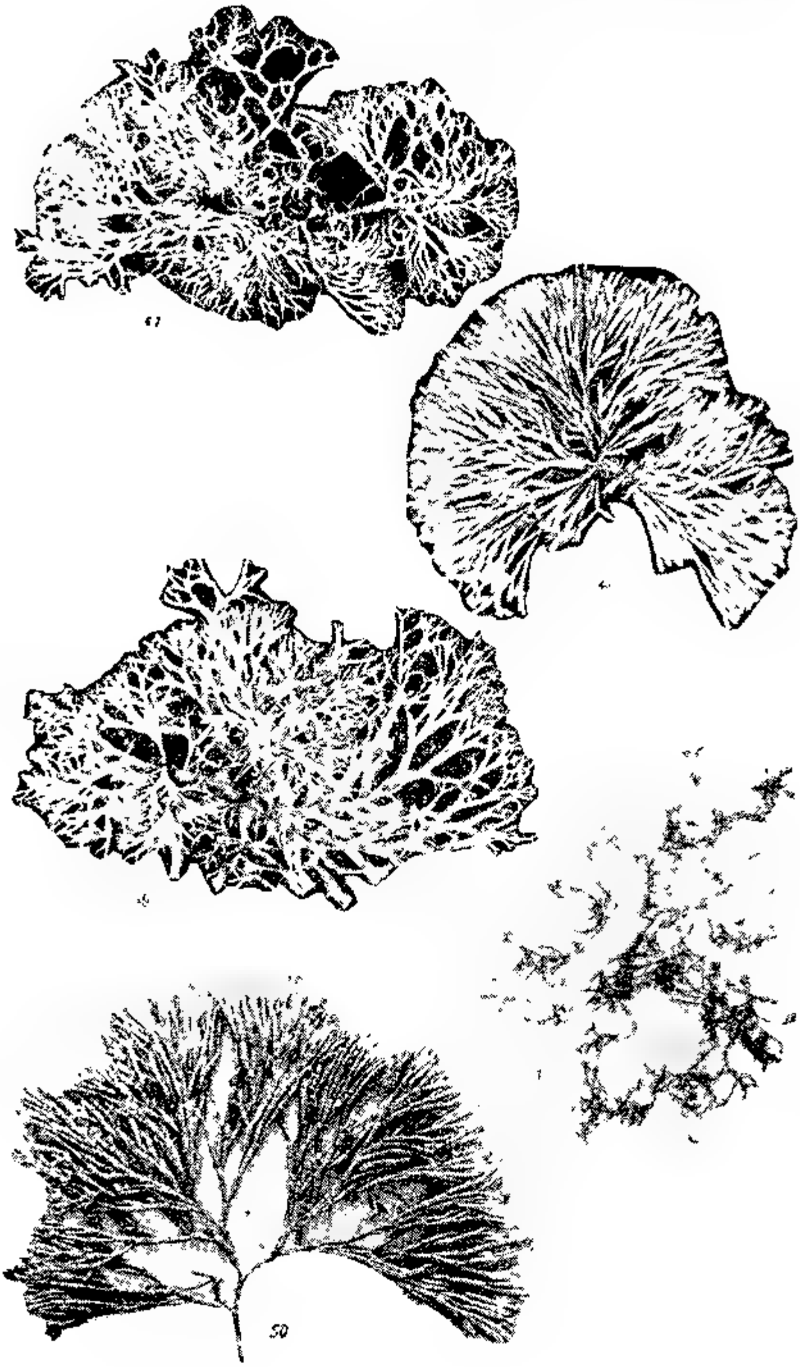
PLATE 9.



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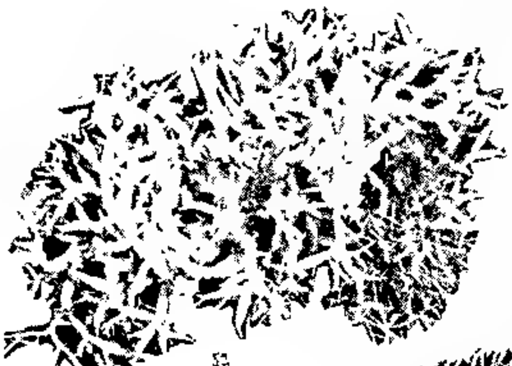

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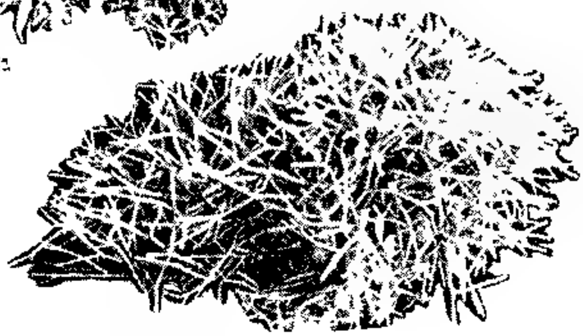

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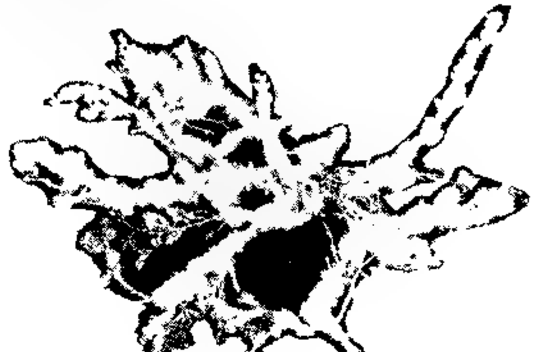

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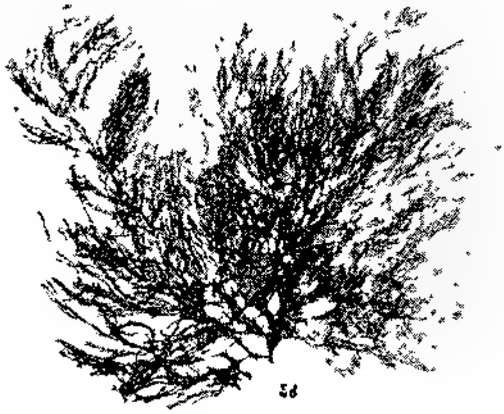
PLATE 11.



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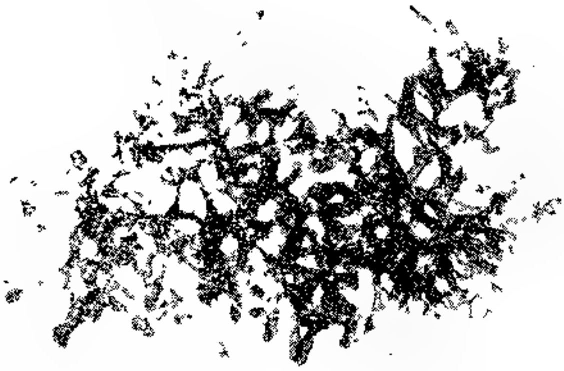

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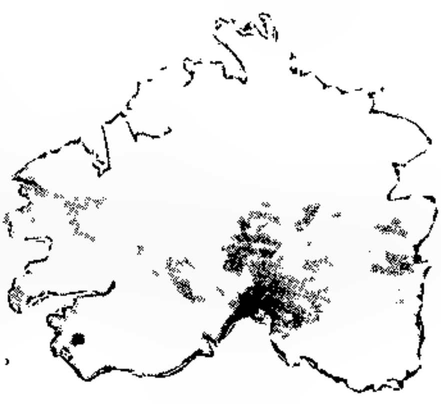

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PLATE 12.

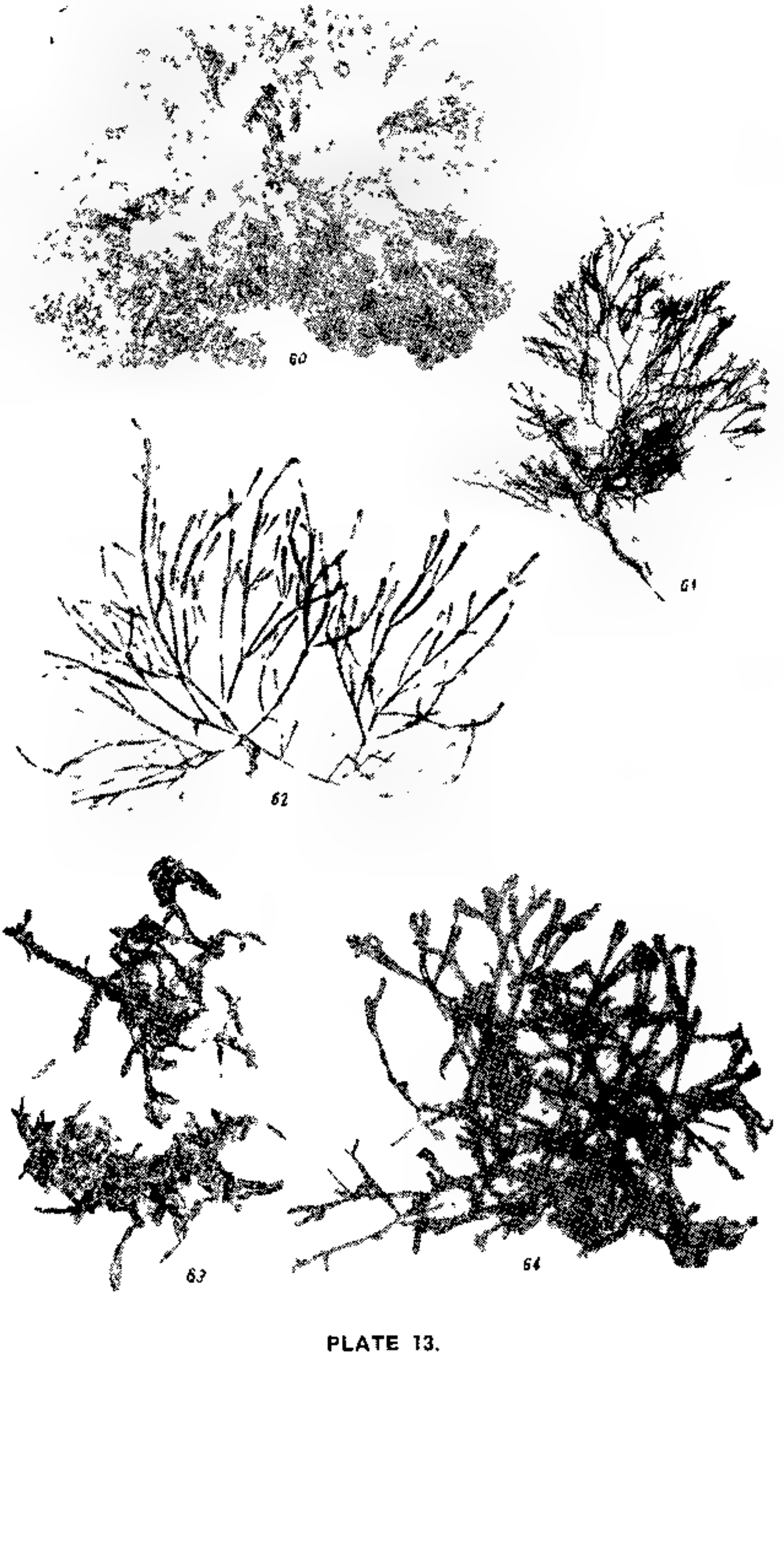

PLATE 13.

PLATE 14.

A STUDY ON THE ISOLATION AND SCREENING OF MICROORGANISMS FOR PRODUCTION OF DIVERSE-TEXTURED NATA

By EMMA GALLARDO DE JESUS, ROLITO M. ANDRES
and ELVIRA T. MAGNO
National Institute of Science and Technology, Manila

TWO PLATES

ABSTRACT

Of the 150 samples screened, 33 nata-forming organisms were isolated: 25 were from rotting sugary fruits, 6 from vegetables, and 2 from a fermenting coconut water-vinegar However, only 14 of the 33 isolates were promising: guava and pineapple isolates gave the highest yields with a mean average thickness of 87.66 cm^3 and 80.70 cm^3, respectively, after 15 days. The other promising isolates came from suha, saba-1, saba-2, orange, santol, latundan-2, mulberry, apple, radish-1, SR coconut water-vinegar, tomato and sineguelas.

Through a Cone Precision Penetrometer and an organoleptic test, saba-1 and sineguelas isolates were found the best producers of soft-textured nata; guava and pineapple isolates yielded a medium-textured nata; the latundan-2 isolate was the best producer of tough-textured nata.

The study of Palo *et al* (1967) and also of Dimaguila, a few months later (1967), have established the correct identity of the microorganism-producing nata to be *Acetobacter xylinum* (Brown) Holland and not *Leuconostoc mesenteroides*, a misidentification. The first team of investigators have studied the ideal conditions under which nata, a cartilaginous substance, could be formed in sugared, coconut-water medium. This valuable study has opened a way of mass-producing nata for preservation in heavy syrup and sold in the market as "nata de coco." The popularity of the product as a favorite dessert has not been confined to local consumption. "Nata de coco" is now gradually being introduced into the foreign market.

Consumers are, however, fastidious and some have expressed preference for soft-textured nata, while others favor medium-textured or a tough-textured nata. The variation in consistency and texture of the nata produced may be attributed to differences in the behavior of the microbial strains used. Speculation on the progress of "nata de coco" manufacturing may not prosper commercially if the demand of different consumers could not be satisfied. To support the growth of this industry, there is an obvious need for research studies to find more high-yielding strains

of the organism that can produce nata of various textural qualities. No work has as yet been done on this subject.

The primary objective of this study, therefore, is to produce nata dessert of different textures — soft, medium and tough using different isolates of nata organism. This report covers only the isolation and selection of high-yielding strains from Philippine microflora.

MATERIALS AND METHODS

Isolation of the nata organism. — One hundred fifty samples consisting of rotting sugary fruits and vegetables, fermenting coconut water-vinegar, juices, saps and syrups collected from different Manila markets, nearby towns and several provinces were used as materials from which the nata-forming organisms were isolated. The organism was allowed to grow by taking a piece of lightly infected portions of the fruits or vegetable in test tubes containing sterile liquid medium of tomato-peptone-yeast-sucrose solution (TPSS),[1] a nutrient medium developed by Palo and Lapuz (1954) for culturing *Streptococcus crystalloides* Palo and Lapuz. The formation of a cartilaginous substance on the surface of the inoculated medium after 5 to 7 days indicate the presence of the nata organism. Isolation was done by using the pour-plate dilution method on TPSS with agar. The isolates were purified by repeated platings and transferred to freshly prepared TPSS agar slants. A similar method was followed in isolating the same organism from fermenting coconut-water vinegar.

Characterization of the isolates. — The different nata isolates were grown in TPSS plates and broth. The inoculated plates and broth were incubated at room temperature for 10 days and observed daily. Some of the morphological features were described as to their appearances in agar colonies and in broth.

Screening of isolates for: a. Textural quality of nata produced. — Thirty-three isolates of nata-forming organisms were screened in the laboratory under aseptic conditions using a pasteurized

[1] Formula of tomato-peptone-yeast-sucrose medium:

Tomato decoction from 250 grams ripe tomatoes

Peptone	5.0 g
Sodium chloride (NaCl)	0.1 g
Magnesium sulfate ($MgSO_4 . H_2O$)	0.2 g
Potassium phosphate, dibasic (K_2HPO_4)	1.0 g
Yeast extract	2.5 g
Sugar	100.0 g
Distilled water q. s.	1000.0 cc
pH of the medium was adjusted to	5.0

sugared coconut water medium,[2] a basic medium previously found favorable for nata formation. The substrate was pasteurized for 45 minutes, and 8 cc glacial acetic acid was added per liter before distribution into sterile bottles in volumes of 150 cc each. Forty-eight-hour-old broth cultures of the different isolates were used as inocula (15 cc volumes) and were seeded into the sterile substrates. Uninoculated bottles served as control. The bottles were incubated at ordinary room temperature (28-31°C) and observed daily for 15 days. The nata formed on the surface of the medium in each bottle was gathered, drained and subjected to textural determination. The "feel method" was employed and this was conducted by pressing the harvested nata in between the forefinger and the thumb. Since this method was inaccurate, a Cone Precision Penetrometer, an instrument which measures the degree of penetrability of greases and petrolatum was used. This instrument can also be employed to determined the softness or toughness of nata as indicated by the readings obtained.

b. *Yield of product.* — Yield was determined by dehydrating the same nata used in textural quality tests with 95-per cent ethyl alcohol and then measured by water displacement in a 1,000-cc glass cylinder.

c. *Eating quality of different-textured nata.* — Based on product yields and textural quality of the nata produced, the selected nata organisms were cultivated separately in 1-liter volume of sugared coconut water medium. Organoleptic test was conducted for each product after cooking in syrup. A testing panel composed of 24 individuals from the Biological Research Center (BRC) and Foods and Nutrition Research Center (FNRC Surveys Division) of NIST determined the texture of the nata produced by each isolate.

RESULTS AND DISCUSSION

Of the 150 samples used, 33 nata-forming organisms were isolated. Twenty-five were from rotting sugary fruits, six from vegetables, and two from fermenting coconut water-vinegar. The various nata-producing isolates and their morphological characteristics are shown in Table 1. It may be deduced that these isolates are different from each other.

[2] Coconut-water medium:

Coconut water	1000.0 cc
Refined sugar	100.0 g
Ammonium sulfate	5.0 g
Glacial acetic acid	8.0 cc
pH of the medium was adjusted to	5.0

TABLE 1.—*Morphological characteristics of some nata-producing isolates*

A. Colonies punctiform

1. Convex, corrugated, entire margin, opaque.
   Apple (*Pyrus malus* Linn.), collected in Paco, Manila.

2. Convex, corrugated, entire margin, translucent.
   Guayabano, corrugated, entire margin, translucent.

3. Convex, smooth, entire margin, opaque.
   Balimbing (*Averrhoa carambola* Linn.), collected in San Andres, Manila
   Calamansi (*Citrus microcarpa* Bunge), collected in Paco, Manila.
   Latundan-1 (*Musa sapientum* var. *cinerea* Linn.), collected in Batangas
   Nangka (*Artocarpus heterophyllus* Lam.), collected in Nueva Ecija
   Papaya (*Carica papaya* Linn.) collected in Cavite.
   Radish-2 (*Raphanus sativus* Linn.), collected in Paco, Manila.
   Saba-2 (*M. sapientum* var. *grandis* Linn.), collected in Aklan.
   Sili Labuyo (*Capsicum frutescens* Linn.), collected in Paco, Manila

4. Flat corrugated, entire margin, opaque.
   Atis (*Anona squamosa* Linn.), collected in Paco, Manila.
   Bungulan (*M. sapientum* var *suaveolens* Blco.) collected in Kalibo, Aklan
   Mango (*Mangifera indica* Linn.), collected in Kamuning, Quezon City.
   Tomato 1 (*Lycopersicum esculentum* Mill.), collected in Kamuning, Quezon City.

5. Flat, smooth, entire margin, translucent.
   Chico (*Achras zapota* Linn.), collected in Paco, Manila.
   Coconut water vinegar (SJ) (*Cocos nucifera* Linn.), collected in San Jose, Paombong, Bulacan.

6. Flat, smooth, entire margin, opaque.
   Orange (*Citrus nobilis* Lour.), collected in Paco, Manila.
   Ratiles (*Muntingia calabora* Linn.), collected in U. P. Los Banos.
   Suha (*Citrus maxima* Burm.), collected in Laoag City.

7. Pulvinate, smooth, entire margin, translucent.
   American pepper (*Capsicum annuum* Linn.), collected in Paco, Manila
   Mulberry (*Morus nigra* Linn.), collected in Baguio City.
   Sineguelas (*Spondias purpurea* Linn.), collected in San Andres, Manila.

B. Colonies circular

8. Convex, smooth, entire margin, translucent.
   Balimbing (*Averrhoa carambola* Linn.), collected in San Andres, Manila

9. Convex, smooth, entire margin, opaque.
   Tomato-2 (*L. esculentum* Mill.), collected in Kamuning, Quezon City.

10. Pulvinate, smooth, entire margin, translucent.
    Duhat [*Syzigium cumini* (Linn.) Skeeds.], collected in Ilocos Norte.
    Guava (*Psidium guajava* Linn.), collected in Kamuning, Quezon City.
    Pineapple (*Ananas comosus* Linn. Merr.), collected in San Andres, Manila
    Radish-1 (*R. sativus* Linn.), collected in Paco, Manila.
    Santol [*Sandoricum koetjape* (Burm.) Merr.], collected in San Andres, Manila
    Strawberry (*Fragaria vesca* Linn.), collected in Baguio City.

11. Pulvinate, smooth, entire margin, opaque.
    Latundan-2 (*M. sapientum* var. *cinerea* Linn.), old isolate of the Biological Research Center.
    Saba-1 (*M. sapientum* var. *grandis* Linn.), collected in Aklan.
    Singkamas (*Pachyrrhizus erosus* Linn.), collected in Paco, Manila.

In TPSS plate agar, for most isolates, very young colonies became noticeable after 72 hours incubation at ordinary room temperature (28-31°C), whereas for *A. xylinum* of Lapuz *et al* (1967), growth in the same medium was visible after 4 to 5 days of incubation. Some young cultures (3-5 days old) of the different nata isolates consisted of individual, transparent or opaque, gelatinous and sometimes mucoid colonies which were punctiform or circular in form. Older agar colonies (6-10 days old) were circular, opaque, convex or pulvinate in elevation, whitish to light brown in color, tough and gelatinous with smooth, glossy surface and an entire margin. Some colonies exhibited a mucoidlike but firm exudate surrounding the organism. Most of the isolates were smooth and mucoidlike and there was no difficulty in tearing the colony apart in contrast with the BRC isolate (latundan-2) which is very tough. As the colonies grew older, some isolates became flattened, slightly wrinkled, darker in color and emitted a characteristic acidic odor. The entire colonies could be easily lifted from the agar when touched with a glowing loop or needle.

The early indication of growth of the nata-organisms in TPSS broth was observed to be slightly turbid after 24 hours incubation. After 48 hours, the formation of a transparent filmy gel on the surface of the medium was clearly visible. The incipient formation of the cartilaginous substance was observed 72 hours after inoculation. This was exhibited by 14 fast-growing isolates (labeled after their corresponding origin): guava (*Psidium guajava* Linn.), pineapple [*Ananas comosus* (Linn) Merr.], suha [*Citrus maxima* (Burm.) Merr.], saba-1 (*Musa sapientum* var. *grandis* Linn.), orange (*Citrus nobilis* Lour.), santol [*Sandoricum koetjape* (Burm.) Merr.], latundan-2 (*Musa sapientum* var. *cinerea* Linn.), mulberry (*Morus nigra* Linn.), saba-2 (*Musa sapientum* var *grandis* Linn), apple (*Pyrus malus* Linn.), radish-1 (*Raphanus sativus* Linn.), SR coconut water-vinegar (*Cocos nucifera*), tomato (*Lycopersicum esculentum* Mill.), and sineguelas (*Spondias purpurea* Linn.) For the slow growing isolates, the incipient formation of nata was observed 4 to 7 days inoculation. As the cultures grew older, the white pellicular or membranous substance thickened on the surface of the medium with the appearance of some threadlike mycelia underneath. The remaining liquid portion of the medium became clear as they aged.

The readings obtained by the penetrometer in the textural determination of the various nata were markedly different as shown in Table 2. It was apparent that the average penetration of the instrument varied widely. This was strikingly indicated in the readings obtained for soft-textured nata formed by saba-1 and sineguelas which was 0.79 mm and 1.68 mm, respectively. From the results obtained by the penetromenter the boundary of readings for tough, medium and soft-textured nata was hard to delineate.

TABLE 2.—*Yield, penetration readings and textural quality of nata produced by different isolates after 15 days incubation at room temperature.*

Isolate numbers	Source of isolates	Mean yield of 4 trials	Mean penetration of 4 trials	Textural quality of cooked nata
		cm^3	mm	
1	Pineapple	80.70	1.09	Medium
2	Ratiles	26.83	1.23	-
3	Strawberry	17.28	*	-
4	Santol	63.13	0.98	Medium
5	Atis	25.88	*	-
6	Orange	63.99	1.22	Medium
7	Tomato	47.50	1.54	Soft
8	Suha	68.44	1.24	Soft
9	Nangka	30.50	1.50	-
10	Guava	87.66	0.91	Medium
11	Duhat	23.12	*	-
12	Apple	53.66	1.98	Medium
13	SJ coconut water vinegar	15.33	*	-
14	Radish-1	49.87	1.26	Medium
15	SR coconut water vinegar	48.33	1.49	Medium
16	Singkamas	46.03	1.23	-
17	Bungulan	42.78	1.22	-
18	Saba-1	65.95	0.79	Soft
19	Saba-2	59.58	0.50	Tough
20	Papaya	22.16	*	-
21	Sili labuyo	36.62	1.31	-
22	American pepper	34.74	*	-
23	Tomato-2	35.41	1.15	-
24	Radish-2	43.62	1.32	-
25	Mulberry	60.66	1.05	Medium
26	Mango	36.94	1.22	-
27	Calamansi	40.79	1.50	-
28	Latundan-2 (BRC)	65.79	1.11	Tough
29	Sineguelas	47.28	1.68	Soft
30	Guayabano	26.76	*	-
31	Chico	26.58	*	-
32	Latundan	25.29	*	-
33	Balimbing	38.12	1.23	-

*,- Too thin very soft.

Results of the experiment on the nata-producing capacity of the 33 isolates are shown in Table 2. Guava and pineapple isolates gave the highest yields with a mean average thickness of 87.66 cm^3 and 80.70 cm^3, respectively. The lowest yield was 15.33 cm^3 obtained from SJ coconut water-vinegar and 17.28 cm^3 from strawberry. Mean average yield of each isolate was obtaiend from four trials with two replications. Plate 1 illustrate the growth of the various nata organisms in sugared coconut water medium after 15 days incubation at ordinary room temperature (28-31°C).

All isolates produced nata but only 14 were promising. The selected nata organisms which are also the fast-growing isolates were selected based on the rate of growth and yield of nata.

Nata produced by the different isolates varied in color — creamy white, creamy yellow to pinkish. The nata formed were smooth and firm, some flabby and fibrous, while others were very soft and slimy that the shape cannot be retained when cut into cubes.

It was observed that all isolates decreased in their rate of growth as the culture aged. This could be attributed to the depletion of available nutrients in the sugared coconut water medium as most of the nutrients were utliized by the organisms. This could also be due to gradual increase of the pH of the medium as a result of the accumulation of waste products of metabolism excreted by the organisms thus weakening their capacity to produce nata considerably.

Results of organoleptic tests on cooked nata are shown in Table 2. Final results based on majority of choice by organoleptic testers revealed that two isolates produced tough-textured nata, eight, medium and three soft-textured nata. The tasting panel selected saba-1 and sineguelas isolates as producers of soft-textured nata and medium-textured nata by guava and pineapple isolates. The old BRC isolate (latundan-2) was chosen as the best producer of tough-textured nata. Plate 2, figs. 1-3 show fully developed colonies of the selected isolates for each type.

The trend of the overall results of the study on the physical and some morphological characteristics of the different nata isolates indicated that these new strains differed considerably from the old BRC isolate (latundan-2) on the production and textural quality of nata. However, the lack of a precision instrument suited for this type of experiment makes it difficult to arrive at a definite conclusion.

SUMMARY

1. Diverse-textured, nata-forming organisms were isolated from rotting sugary fruits, vegetables and fermenting coconut-water vinegar. Of the 150 samples screened, 33 nata-forming organisms were isolated; 25 were from rotting sugary fruits; six from vegetable, and two from a fermenting coconut water-vinegar.

2. The 33 isolated nata-forming organisms were tested for their quick nata-producing capacity. Only 14 isolates were promising: guava and pineapple isolates gave the highest yields with a mean average thickness of 87.66 cm^3 and 80.70 cm^3; respectively. The other isolates were from suha, saba-1, saba-2, orange, santol, latundan-2 (BRC isolate), mulberry, apple, radish-1, SR coconut water-vinegar, tomato, and sineguelas.

3. The textural quality of nata produced by the selected isolates was determined by the use of a Cone Precision Penetrometer and organoleptic test. Results showed that saba-1 and sineguelas isolates were found best producers of soft-textured nata. Guava and pineapple isolates yielded a medium-textured nata. The BRC isolate (latundan-2) was chosen as the best producer of tough-textured nata.

4. Based on physical and morphological characteristics of the different nata isolates, the new strains isolated varied considerably in yield and textural quality of nata as compared to the old latundan-2 isolate.

ACKNOWLEDGMENT

The authors are grateful to Mr. Macario A. Palo, former Director and Technical Consultant on Industrial Microbiology of the Biological Research Center, NIST, for his interest in initiating this study; to Mrs. Luz Baens-Arcega for her invaluable suggestions and for reading the manuscript, and to Mr. Armando T. Coronel of the Test and Standards Laboratory for the use of the Cone Precision Penetrometer.

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ILLUSTRATIONS

[The pictures in Plates 1-2 were taken by Ricardo Marquez, scientific photographer, National Institute of Science and Technology.]

PLATE 1

Fifteen-day-old culture of the different nata isolates forming diverse-textured nata in sugared coconut water medium.

PLATE 2

Showing fully-developed colonies of the selected isolates for each type on tomato-peptone-yeast-sucrose agar.

FIG. 1. Soft-textured nata isolate produced by saba-1.

2. Medium-textured nata isolate produced by pineapple

3. Tough-textured nata isolate produced by latundan-2.

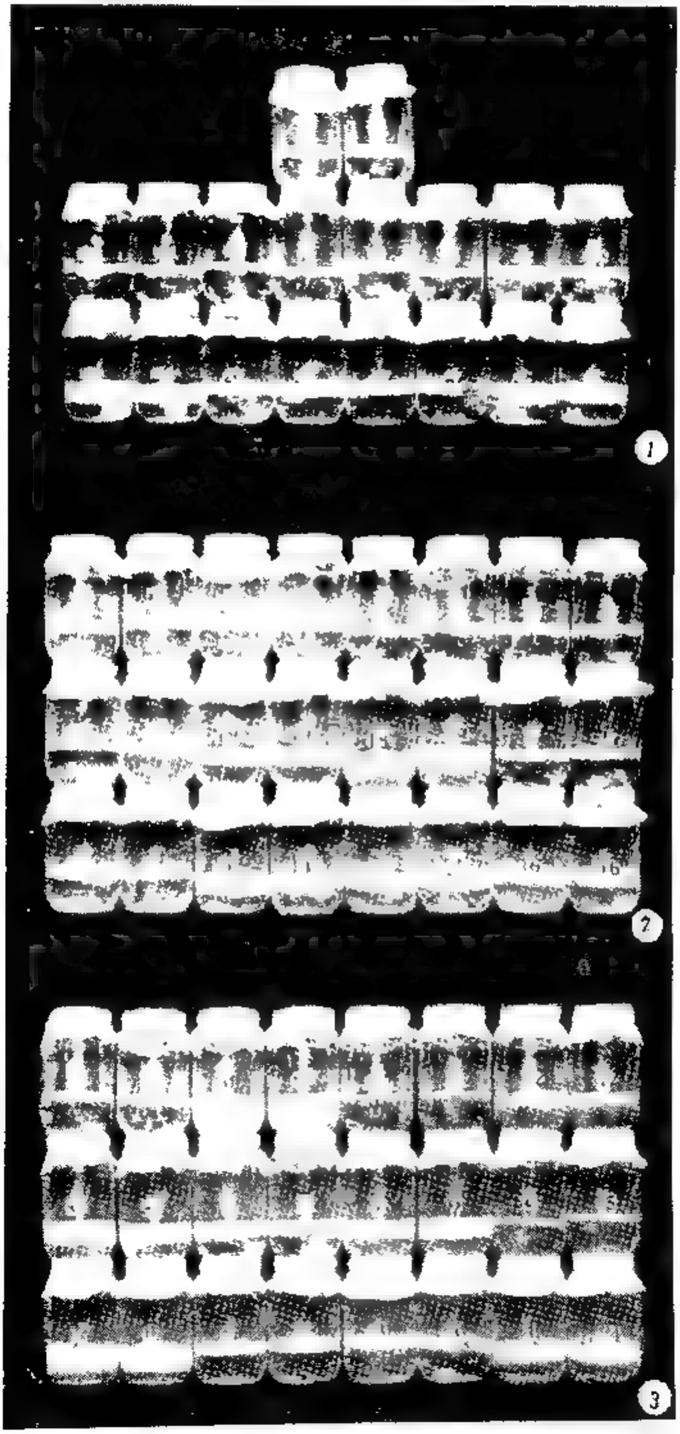

PLATE 1.

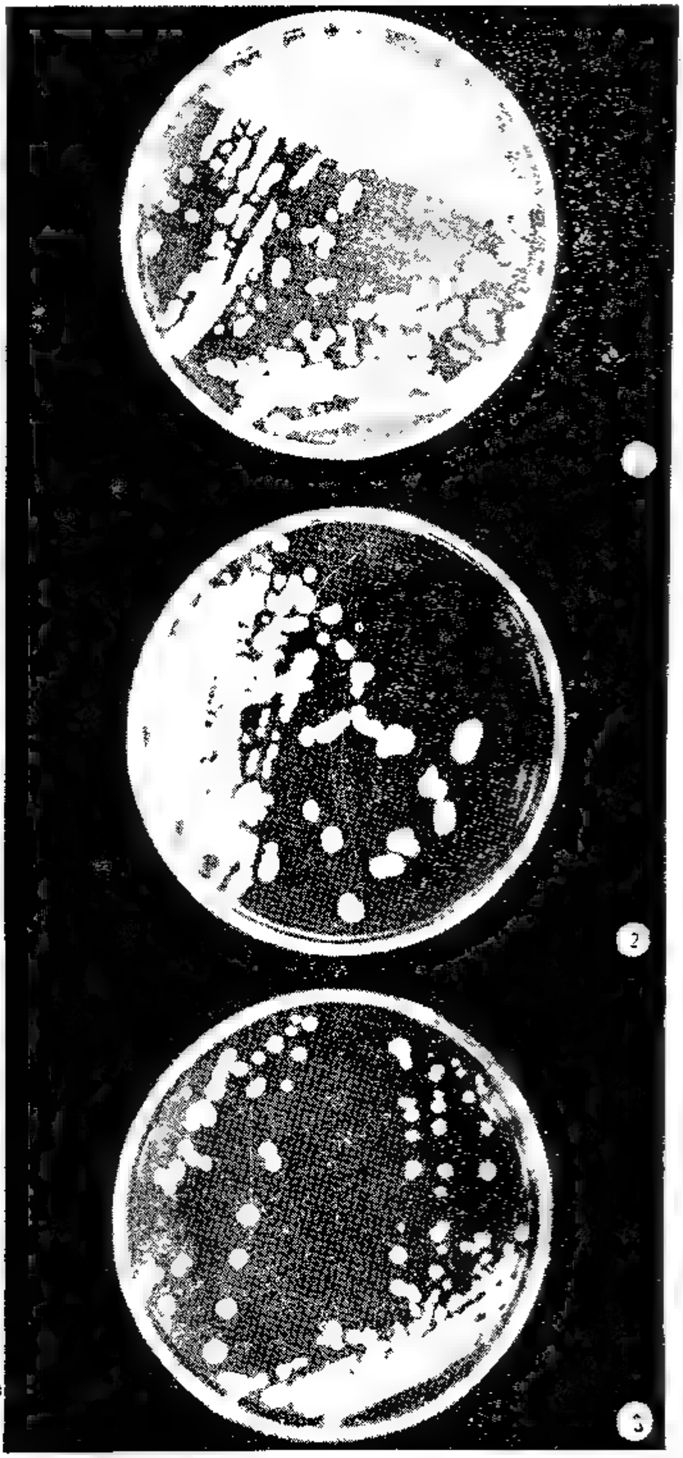

PLATE 2.

ON PHILIPPINE MOSQUITOES, IV. A NEW SPECIES OF ARMIGERES, SUBGENUS ARMIGERES (DIPTERA: CULICIDAE)

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FOUR TEXT FIGURES

ABSTRACT

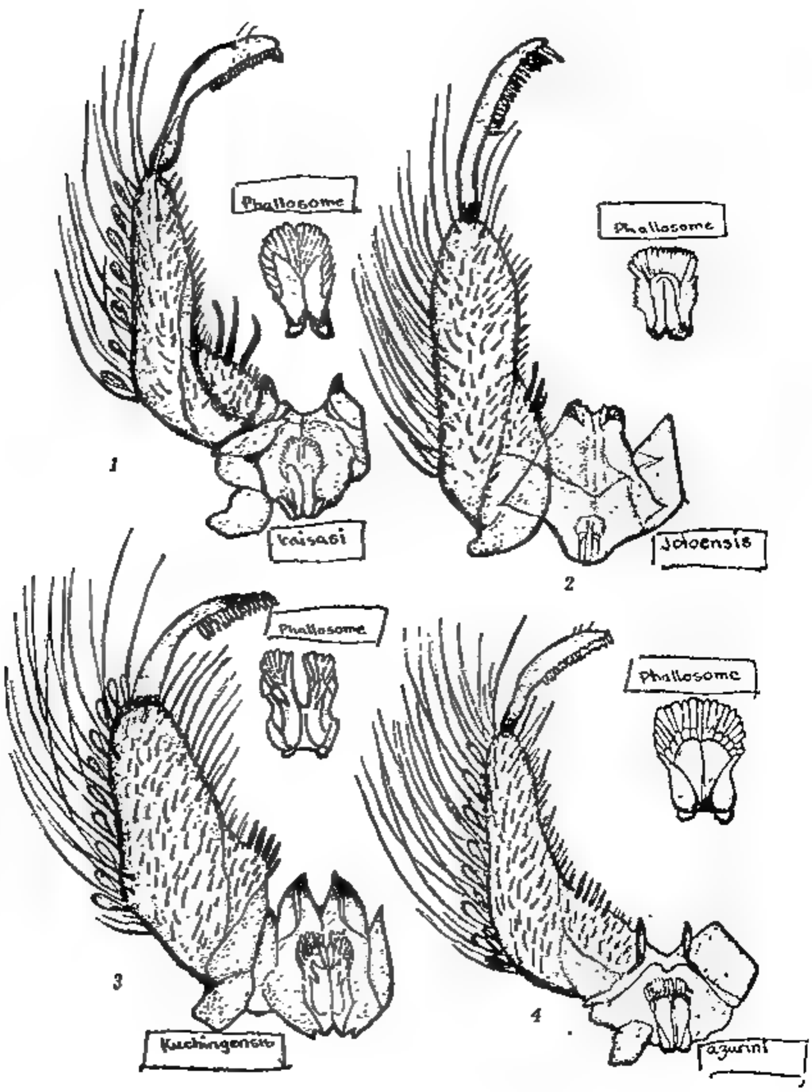
A new species named *Armigeres (Armigeres) azurini* is described. The male terminalia of the new species and three related species, *Armigeres (A.) baisasi* Stone and Thurman, *Armigeres (A.) jolœnsis* (Ludlow), and *Armigeres (A.) kuchingensis* Edwards are illustrated for comparison.

This species was already included in the senior author's recent publication entitled "The Mosquito Fauna of the Philippines" (1971), even before the formal description of the species.

Among the mosquito collections from Mt. Makiling was a single male specimen which in general habitus appeared like *Armigeres (Armigeres) baisasi* Stone and Thurman. According to Stone and Thurman (1958) and Delfinado (1966), a related species *Armigeres (Armigeres) kuchingensis* Edwards may be separated from *Armigeres (Armigeres) baisasi* by the subapical white band on sternite VII in the former species, the band being apical in the latter species. The new species has an apical white band on sternite VII. However, *azurini* could be reliably differentiated from the related species by careful examination of the structure of terminalia and other important taxonomic characters. The new species *A. azurini* (Fig. 4) differs distinctly in the shape of terminalia from those of *A. baisasi* (Fig. 1), *A. jolœnsis* (Fig. 2), and *A. kuchingensis* (Fig. 3). Stone and Thurman (1958) report that *kuchingensis* is not present in the Philippines.

ARMIGERES (ARMIGERES) AZURINI sp. nov.

Male.—Medium size. Wing about 3.5 to 4.0 mm long. Head: Dorsum covered with white scales, with a few dark scales laterally; some dark and pale erect scales present on nape. Proboscis dark with a few pale scales ventrally. Palpus dark and longer than proboscis by half the length of last segment. Torus white-scaled with a few brownish scales on innerside. Clypeus scaly. Thorax: Mesonotum with dark and brownish scales; mesonotal border white with few dark scales. Prescutellum with



FIGS. 1 4. *1, A. baisasi; 2, A. jolœnsis; 3, A. kuchingensis;* and *4, A azurini*.

median white spot not extending to midlobe of scutellum; scutellar lobes covered with flat, dark and pale scales. Anterior pronotal lobe (Apn) and posterior pronotal lobe (Ppn) with white scales. Front coxa almost entirely covered with white scales, underside with a few brownish scales. Propleuron with white scales

but sparse laterally. One lower mesepimeral bristle present. Legs: Pale scales present on undersides of femora. Tarsi dark with brownish luster. Hind claws simple and equal in size. Abdomen: Tergites dark with median pale basal markings on II to VI; tergites II to III with white or pale scales laterally but not forming a straight line; tergite VIII with a basal spot. Sternites II to VI centrally covered with white scales, laterally with a few pale scales; sternite VII mostly pale except for dark base and white apical band.

Male terminalia (*Fig. 4*).—Basistyle slender; dististyle short, expanded medially, but not reaching base of setæ of claspette when pressed against basistyle; dististyle with 14 to 15 teeth on apical half; apical tooth almost equal with others; claspette with four to five sharp setæ not curving toward basistyle.

Female.—Unknown at present.

Pupa.—Only two pupal skins were retrieved from six larvæ collected.

Larva.—At present, the immatures of this species cannot be separated with certainty from larvæ of *Armigeres baisasi.* Only six larvæ were collected from a papaya stump (*Carica papaya* Linn.) with "soapy" organic matter. Only two larval skins were saved.

More intensive and extensive collection is being done at present to obtain materials for a detailed study of the immatures.

Holotype.—One male, Mount Makiling, Laguna Province, Luzon Island, 230 feet elevation, collected March 24, 1969 by Dennis W. White; deposited in the Philippine National Museum, Manila.

The male type was net-collected while resting on a decaying papaya stump.

Distribution.—Known only from the type locality.

Taxonomic discussion.—The new species is superficially like *Armigeres baisasi* Stone and Thurman in having a white apical band on sternite VII, a basal white spot on tergite VIII, and one lower mesepimeral bristle; the medially expanded dististyle does not reach the base of setæ of claspette when pressed against basistyle. However, the scale pattern on the torus, clypeus, nape, propleuron, femur, tarsi, and the simplicity of the hind claws are different. Furthermore, the dististyle of the new species has 14 to 15 teeth that are about equal in size. In *Armigeres baisasi*, there are 19 to 20 teeth with the apical tooth longer than the rest. In

addition, *Armigeres azurini* has four to five sharp and straight setæ that do not curve toward the basistyle, while *Armigeres baisasi* has two to three that curve toward the basistyle.

Remarks.—This species is named in honor of Dr. Jesus C. Azurin, director, Bureau of Quarantine, Philippine Department of Health, in recognition of his untiring research studies on Cholera El Tor.

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ANATOMY OF SOME BAMBOO SPECIES IN THE PHILIPPINES

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EIGHT PLATES AND TWO TEXT FIGURES

ABSTRACT

The anatomy of five bamboo species, thriving in the Philippines, comprising three of the erect group, namely, kawayan-kiling (*Bambusa vulgaris* Schrad. ex Wendl.), kawayan-dilaw [*B. vulgaris* var. *striata* (Lodd.) Gamble] and bayog (*Dendrocalamus merrillianus* Elm.) and two of the climbing group, like *Dinochloa scandens* auctt. non O. Kuntze and bikal [*Schizostachyum diffusum* (Blanco) Merr.] was investigated. Based on the shape, size, and arrangement of the vascular bundles, the erect bamboo species could be specified and segregated. However, the climbing species were difficult to differentiate due to lack of qualitative anatomical differences.

INTRODUCTION

Bamboo, comprising 600 to 700 species, are represented by about 60 genera. These are found throughout the world, but mostly in southern and southeastern Asia, from India to China and Japan to Korea. Of these 33 bamboo species reported in the Philippines, including exotic ones, 20 are erect; others are of the climbing type [Salvosa (1963)]. The erect bamboo species are represented by the genera *Arundinaria*, *Bambusa*, *Dendrocalamus*, *Gigantochola*, *Guadua*, *Phyllostachys*, and *Schizostachyum*. The last genus contains also climbing species.

The classification of bamboos is based on the morphology of the flowers and fruits. Recently Holttum (1956) commented that the present systems of classification of bamboos appear unnatural. Consequently, he proposed a new scheme of classification based on the structure of ovary. However, a classification based mainly on the reproductive features, is not entirely satisfactory for identification of standing culms because most species flower once in their lifetime and then die. So, a thorough investigation on the morphological characteristics of the vegetative organs of bamboos with emphasis on the culm sheaths was conducted

[Chatterji and Raizada (1963)]. But this work was not always effective in the identification of culms because of considerable variation of the culm sheaths even in the same species and because of overlapping characters among different species and genera.

It would certainly be a "breakthrough" in the advancement of research, if bamboos could be segregated or identified not through mere morphological structures but more so through their anatomical structures. However, the literature on the anatomical studies of bamboos is meager. Studies on the gross anatomy of bamboo culms were carried out by several investigators [Bhargava (1962), Ghosh and Negi (1959-60), Ota and Sugi (1953), Schwendener (1874), Strasburger (1891), and Takenouchi (1931-31a)]. Also, investigations were conducted on the arrangement of fibers, parenchyma, vessels, and sieve tubes on a quantitative basis [Liese and Grover (1961), Liese and Mende (1969), Yu and Chang (1963)].

There were first few attempts to segregate or identify bamboo species through their anatomical structure [Metcalfe (1960), Samapuddhi (1959), Velasquez and Santos (1931)]. Great differences in the anatomical structure were observed among internodes of a given culm [Ghosh and Negi (1959), Li and Chin (1960), and Li *et al* (1962)]. Also, there were variations in the anatomical structure in various internodes within a culm [Grosser (1965), Patanah and Ramesh Rao (1969)]. The first key to the anatomical structures of bamboos differentiated 24 Chinese species [Li and Chin (1960) and Li *et al* (1962)].

In a detailed study on the anatomy of bamboos, Grosser (1970) investigated 1,200 internodes from 250 culms, represented by 52 species and 14 genera of bamboos, collected from seven Asian countries. Results of this study clearly demonstrated the necessity of investigating systematically several internodes, representing the consecutive changes of the anatomical structure from the base to the top of a given culm. A good workable key for the anatomical structures could be effectively realized when due consideration is given to the variability of the size, shape, and arrangement of the vascular bundles within a culm. Grosser's classification, based on the anatomical structures, is in accordance with a new classification, based on the structure of ovaries [Holttum (1956)]. This conformity proves that the introduced classifications by Munro, Bentham, Hackel, Gamble, E. G. Camus, A. Camus, etc. do not correspond with facts.

These results are regarded as important to further the identification of Philippine bamboos in order to learn their anatomical setup and to include these species into the system by Grosser (1965) and Holttum (1956).

MATERIALS AND METHODS

The materials used in this investigation were authentic, mature, and sound culms from erect and climbing bamboo species, collected mainly by Prof Dr. W. Liese in the Philippines, East Pakistan, and Indonesia. Kawayan-kiling (*Bambusa vulgaris* Schrad. ex Wendl.) and bayog [*Dendrocalamus merrillianus* (Elm.) Elm.] represented the erect bamboo group; and bikal [*Schizostachyum diffusum* (Blanco) Merr.], the climbing bamboo group. In addition the erect bamboo species kawayan-dilaw [*bambusa vulgaris* Schrad. var. *striata* (Lodd.) Gamble] was studied to compare particularly the arrangement of its vascular bundles with the closely related kawayan-kiling Likewise, bikal was compared with *Dinochloa scandens* auctt. non O. Kuntze to determine whether climbing bamboos have generally conspicuous and significant qualitative anatomical features The materials studied and the collection data are listed in Table 1.

TABLE 1—*List of bamboo species examined.*

Species	Origin	Number of culms
I *Erect bamboo species:*		
1 *Bambusa vulgaris* Schrad ex Wendl	East Pakistan, Indonesia, and Philippines	12
2. *B. vulgaris* Schrad. var. *striata* (Lodd) Gamble	Philippines	2
3 *Dendrocalamus merrillianus* (Elm.) Elm	Philippines	3
II *Climbing bamboo species:*		
1. *Dinochloa scandens* auctt. non O. Kuntze	Indonesia	2
2. *Schizostachyum diffusum* (Blanco) Merr.	Philippines	1

From the erect bamboo culms with about 20 to 50 internodes, the second internode, beginning from the base, and every following fourth internode were selected for the study. From the middle portion of these internodes, a ring of culm measuring

two cm wide was taken. For every ring, two block (one cm wide) were prepared. The system of selecting samples for anatomical study is shown in Fig. 1.

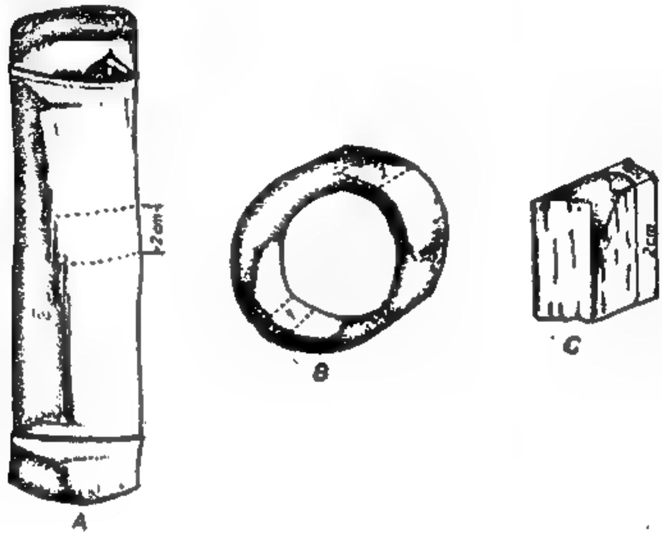


FIG. 1. A selected internode (*A*), a ring of culm (*B*), and a bamboo block (*C*) for anatomical study.

Two methods of preparation proved successful and effective in softening the materials; namely, the use of autoclave and suction pump followed by boiling [Grosser (1970)]. The blocks of erect bamboos were placed in an autoclave set at 120°C for 3 to 4 hours. The climbing bamboos, on the other hand, could be cut after being suctioned for 20 minutes and boiled for 30 minutes. With the desired consistency of softness attained, the blocks were placed in 70-per cent alcohol. Transverse sections of 30 to 60 microns thickness were cut with a sliding microtome. The sections were stained in astra blue and acridine-chrysoidin red solutions and permanently mounted in Entellan.

To illustrate the size, shape, and arrangement of the vascular bundles of the different bamboo species studied, photomicrographs and drawings were prepared [Grosser (1970)].

RESULTS

Anatomical structure of erect bamboo species. — The gross anatomical structure of a transverse section of any internode of a bamboo culm is visible to the naked eye or at low magnification with a hand lens In a culm-wall lies a great number of dark vascular bundles, distributed throughout the entire length of the culm. The bundles are clearly contrasted with a light-colored ground tissue, resulting in a decorative pattern (Plate 1, fig 1). A striking feature is the dense grouping of numerous small vascular bundles near the periphery and the gradual increase in loose arrangement of vascular bundles towards the inner part of the culm-wall. The anatomical structure is determined by the shape, size, arrangement, and number of vascular bundles.

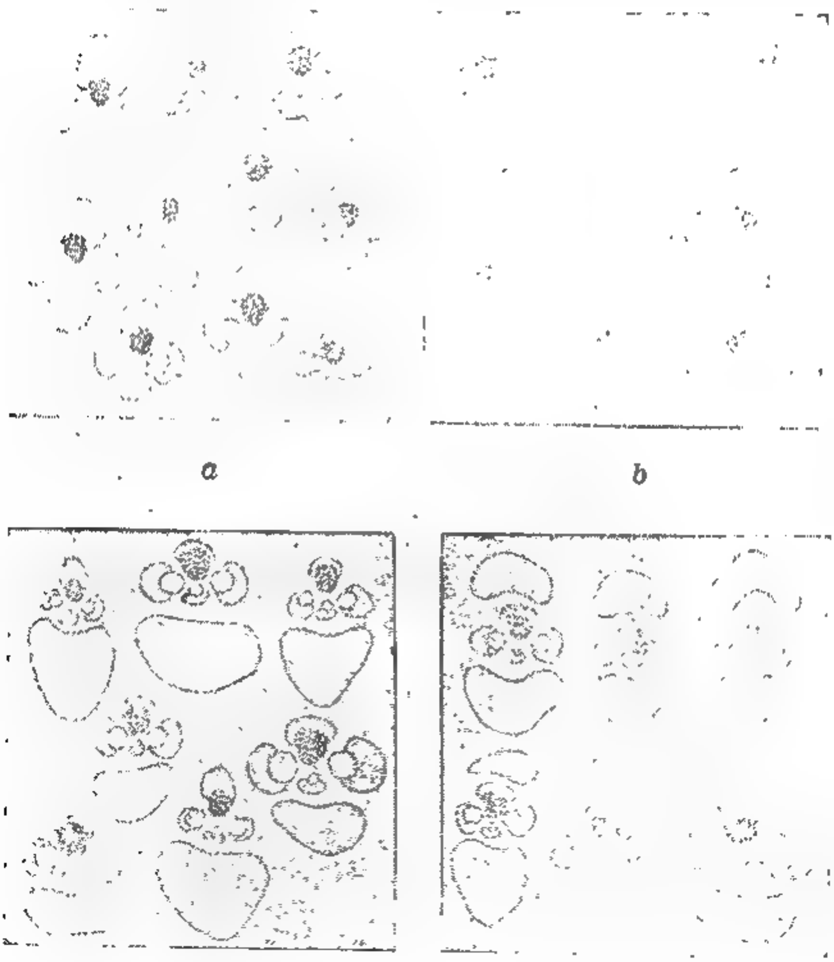
The bamboo culm tissue consists of the following cell types: (*a*) parenchyma, (*b*) sclerenchyma, (*c*) vessels, and (*d*) sieve tubes and companion cells. The mass of parenchyma cells builds up the ground tissue, while the sclerenchyma cells, vessels, vascular parenchyma, sieve tubes, and companion cells unite together and comprise the vascular bundles Hence, two types of tissues can be differentiated: (*a*) parenchymatous ground tissue and (*b*) vascular bundles. All cells of the two types of tissues are invariably oriented in vertical direction. Radial rows of cells similar to the wood rays are absent.

In the transverse section, a complete and fully differentiated vascular bundle, occurring in the middle and inner portion of the culm-wall, is as follows:

The metaxylem, oriented towards the central cavity, consists of two symmetrically-arranged vessel elements. Inward arises an intercellular space in which a single ring of primary xylem vessels is sometimes noted. The orientation of the two large vessel elements and the intercellular space show a V-shaped pattern, between which may exist one or more small xylem elements. The phloem is oriented towards the periphery and disconnected from the vessels by a few rows of parenchymatous cells without a cambium. This consists of thin-walled, unlignified sieve tubes with several companion cells (Plate 1, fig. 2).

The phloem and the xylem portions of the vascular bundles, surrounded by sclerenchymatous sheaths or caps, differ in thickness from species to species and also from their position in the culm In general, each vascular bundle in the middle and inner

portion of the culm-wall possesses four caps. Two of the caps are laterally located on either side of the vessels; the other two caps are polarly situated on the outer part of the phlœm and inner part of the intercellular space. Aside from the caps, a great number of bamboo species have also isolated fiber bundles or fiber strands present inside, or both inside and outside of the central strands, containing the vascular elements (Figs. 2*c* and 2*d*). Consequently, a double arrangement of the fibrous tissue is distinguishable — on one side, fiber sheaths (fiber caps) and on the other, fiber strands (fiber bundles).



a *b* *c* *d*

FIG. 2. Different types of vascular bundles: *a*, general Type I; *b*, general Type II; *c*, general Type III; and *d*, general Type IV.

These bamboo species whose fibrous tissues are limited to the caps have vascular bundles consisting of one part, the central strand (vascular strand), (Figs. 2*a* and 2*b*). In contrast, those with fiber strands have vascular bundles composed of two or three parts, namely: the central strand and either one fiber stand or two fiber strands (Fig. 2*c* and 1*d*). So far, the vascular bundles of Asian bamboo species could be classified into four general types (Fig. 2*a*–2*d*), which are designated as Types I, II, III, and IV [Grosser (1970)].

The distribution of vascular bundles indicates the typical irregular arrangement of the structural tissue of the monocots. The shape, size, number, and arrangement of the vascular bundles are modified from the peripheral region towards the inner region of the culm-wall (Plate 3). The vascular bundles continuously decrease in size, but increase in number towards the periphery of the culm, thereby compactly crowding each other. Inwards, the vascular bundles turn out to be larger and appear more loosely arranged. In the middle portion of the culm-wall, the vascular bundles attain maximum size and exhibit a characteristic shape for each bamboo species (Figs. 2*a*–2*d* for the general types). In the innermost part of the culm-wall, these become smaller again and are often disoriented.

The entire transverse section can be divided arbitrarily into four vascular bundle-regions: (*a*) peripheral region, (*b*) transitional region, (*c*) central region, and (*d*) inner region. To determine the extent covered by the four vascular bundle-regions, it is advantageous to apportion the transverse section into three equal parts, i.e., outer, middle and inner.

As a rule, the central region is the broadest and the vascular bundles localized herein, extensively determines the anatomical structure of the transverse section. But each of the remaining three vascular bundle-regions may also have typical features of important diagnostic value for those species with the same general types of vascular bundles.

By arranging side by side all typical forms of vascular bundles, represented from the periphery to the central cavity in a straight horizontal line, the variation of shape and size of the vascular bundles in the transverse section is clearly reflected in the two diagrams of vascular bundles belonging to *B. vulgaris* and *D. merrillianus*, Plates 6 and 8.

A principal anatomical criterion which up to now is not given due consideration is the continuous modification of the anatom-

ical structure at different height levels of the culm. Shape, size, arrangement, and number of vascular bundles vary considerably, thus, revealing a completely different pattern in anatomical structure from the base to the middle internodes, and often from the middle to the top internodes of a culm. Because of this trend of variation, it is obviously necessary to conduct a thorough investigation on a bamboo species, making anatomical descriptions, based on several internodes from different parts of a given culm Following are the descriptions for the bamboo species investigated

BAMBUSA VULGARIS Schrad. ex Wendl.

Philippine official common name: Kawayan-kiling

Morphology· Pachymorph; more or less compact clumps; culms spineless, medium-sized, 6 to 15 m high., diameter, 5 to 12 cm; culm-wall thickness of base internodes, generally 7 to 15 cm.

Anatomical structure: The cortex is homogenous, constructed of thin-walled cells which are larger than the epidermal cells in the base internodes but smaller in the top internodes. In all internodes of the culm, a broad inner concluding tissue consisting of 6 to 12 layers of cells is present. The concluding tissues are rectangular and tangentially arranged. The middle and top portions of the culm always have thicker walls than the parenchymatous ground tissue. The concluding cells sometimes appear sclerosed in older culms.

Due to the small vascular bundles (maximum radial diameter, 1.2 to 1 3 mm; maximum tangential diameter, 0 7 to 1.0 mm), *B. vulgaris* is clearly differentiated from *D. merrillianus*. The vascular bundles of Type IV are only found in the base internodes near the ground, while the general Type III exists in the middle and top internodes vascular bundles. The vascular bundles at the base internodes are radially elongated and those at the middle and top internodes are often roundish (Plates 3, 5, and 6)

B. vulgaris Schrad. var. *striata* is morphologically distinguished from the normal and closely related *vulgaris* variety by its striking green striped culms There are no significant anatomical differences between them since the structure of the vascular bundles are similar.

Central region.—In most cases, base internodes with wall thickness between 15 to 17 mm in the outer part of the central re-

gion have regularly developed vascular bundles of the general Type IV; inward the culm-wall, Type III dominantly exists aside from Type IV. Throughout the entire central region vascular bundles exclusively of Type IV (Plate 5) are noted, except for very thick-walled culms thicker than 17 mm. On the contrary, very thin-walled culms with wall thickness from 10 to 15 mm at the base internodes have usually few vascular bundles of Type IV. In thick-walled culms, the outer fiber bundles are somewhat kidney-shaped and almost as broad as the central strand. Likewise, the inner fiber strands are slightly differentiated in width from the central strand. In smaller culms, however, the outer and inner fiber bundles have, as a rule, smaller tangential diameters than the central strands. The vascular bundles of Type III in the base internodes have often radially elongated phloem caps which are comparatively larger than the caps of the two metaxylem vessels.

In the succeeding internodes where the culm-wall attains a thickness of 10 to 12 mm (between the 6th and 10th internodes), only vascular bundles of the general Type III are found. The central strands are mostly somewhat broader than the fiber bundles in the middle and top internodes. The latter are roundish, becoming at first broad-oval inward the culm-wall and, finally, turning into flat-oval. Opposite the intercellular space, the fiber bundles are seldom in a deep concave or notchlike shape. The metaxylem caps and the phloem caps are relatively small and not essentially different in size. The protoxylem caps are always small and inconspicuous.

Inner region.— Small, reduced in size, and disoriented vascular bundles are found in the base internodes. The inner vascular bundles of the middle and top internodes are broader than long and flat-oval. The lateral fiber sheaths are greater than the polar sheaths. In the top internodes of some culms, sometimes there are vascular bundles with small, flat-oval or roundish inner fiber bundles.

Transitional region.—Generally, in the base internodes towards the periphery, the outer fiber bundles and the phloem caps first fuse and, finally, the inner fiber bundles and the three xylem caps combine into one large cap, which is always bigger in size than the phloem cap. In the transitional region of thin-walled internodes, representing the middle and top portions of the culm, the three xylem caps and the fiber bundles coalesce simultan-

eously, but not successively as in *D. merrillianus*. The transitional vascular bundles in all internodes of the culm are radially elongated or longer than wide.

Peripheral region.—In the base internodes towards the cortex lie small, roundish, and loosely-arranged vascular bundles consisting of two prominent vessels. Also, the peripheral vascular bundles of the middle and the top internodes are somewhat rounded, but compactly and tangentially arranged in a chain, located between the outer vascular bundles which are simple fiber groups without vascular elements but which are smaller than the vascular bundles.

DENDROCALAMUS MERRILLIANUS (Elm.) Elm.

Philippine official common name: Bayog.

Morphology: Pachymorph; slender spineless stalks forming into large clumps that are open or loosely tufted, with culms bending over; culm height 15 to 18 m; diameter generally from 6 to 10 cm; very thick-walled in the base internodes, 25 to 35 mm or more.

Anatomical structure: The homogeneous cortex is strikingly broad, consisting of thin-walled cortex cells which are (except for the first two or three layers) essentially larger than the epidermal cells. Only in the top internodes are the epidermal cells sometimes larger than the cortex cells. The inner concluding tissue has also many layers but could be hardly differentiated from the parenchymatous ground tissue. The concluding cells are thin-walled and radially flattened, thus rectangular in shape. The internodes at the top of the culm may have thick-walled to sclerosed concluding cells.

D. merrillianus (Plates 7-8) exhibits larger vascular bundles (maximum radial diameter, 1.5 to 1.6 mm; maximum tangential diameter 1.1 mm) in all parts of its culms as compared to *B. vulgaris*. The characteristic feature of *D. merrillianus* is that the vascular bundles are of general Type IV, not only in the base internodes but also in the middle and top internodes This is in contrast to most of the species in the genera *Bambusa* and *Dendrocalamus*. In all parts of the culm, the vascular bundles are radially elongated.

Central region.—In the base and middle internodes of the culm, vascular bundles are exclusively of Type IV. Because these are seldom reduced or disoriented, the tissue as a whole is homogeneously structured. Vascular bundles of Type III, aside from

those of Type IV, are found only in the top internodes of the culm (Plates 7-8). In the base internodes, the outer and inner fiber bundles are slightly different in size. Generally, the outer fiber bundles are bean-shaped or broader than long and clearly forming an arc. On the contrary, the inner fiber bundles are oval-shaped or less intensively curved or bent. They are often confined opposite the intercellular space. The central strand and the fiber bundles have approximately the same tangential diameter (Plates 3, 7, and 8). Within the entire length of the culm, the size of the outer fiber bundles decreases faster than those of the inner fiber bundles. Therefore, in the middle and top internodes, the latter are larger than the former (Plates 7 and 8). The outer fiber bundles are oval, roundish or triangular; the inner are broad to flat-oval. The fiber bundles are sometimes notched opposite the intercellular space. The central strand has a larger diameter than the inner fiber strand. It is also essentially larger than the outer fiber bundle.

Inner region.—The base internodes have relatively less disoriented and reduced vascular bundles than the middle or top internodes, and the inner region is inconspicuously developed. In contrast to *B. vulgaris*, the innermost vascular bundles of the middle and top internodes have often small inner fiber bundles and sometimes small outer fiber bundles too, appearing like Type III and Type IV. Both the outer and inner fiber bundles have shapes varying from roundish to flat-oval. The metaxylem and phlœm caps are subequal in size. The protoxylem caps are small and inconspicuous.

Transitional region.—In the base internodes, the three xylem caps and the inner fiber bundles, as well as the phloem caps and the outer fiber bundles, merge more or less simultaneously, whereby, large "hooklike" caps are often formed. The caps which are located more towards the outer part of the culm-wall often exhibit patches of parenchyma cells. In the middle and top internodes, the two metaxylem caps and the protoxylem cap frequently unite first, forming a broadlike sheath before fusing with the inner fiber bundle. Simultaneously, the phloem cap and the outer fiber bundle merge. These phloem caps are larger than those of *B. vulgaris;* however, like the aforementioned species, they are always smaller than the xylem caps. The transitional vascular bundles are, as a rule, longer than wide.

Peripheral region.—The base internodes exhibit small, roundish vascular bundles in the outermost portion of the wall. The xylem

and phloem elements are surrounded by a ringlike fiber sheath. The middle and top internodes have vascular bundles which are slightly larger than those of the base internodes and compactly crowded and arranged in straight tangential direction. They are roundish or sometimes oval. Generally, the outer vascular bundles are smaller than those of *B. vulgaris*. Likewise, the simple fiber groups between the outer vascular bundles which are typically occurring in the middle and top internodes of *B. vulgaris* are normally absent in *D. merrillianus*.

ANATOMICAL STRUCTURE OF CLIMBING BAMBOO SPECIES

The structure of the climbing bamboos, represented by the genera *Dinochloa* and *Schizostachyum*, is easily distinguished from the erect bamboo species. In the inner culm-wall, the anatomical structure is determined by vascular bundles having two metaxylem vessels with extremely great diameters, a large, elongate-oval phloem, and only a small intercellular space. As a characteristic feature, the fiber tissue is limited to very small sheaths and sickle-shaped fiber bundles (Plate 2).

As a rule, *D. scandens* has only outer fiber bundles, while *S. diffusum* has outer and inner fiber bundles, often separated by parenchymatous cells into several small fiber groups (Plate 2). In both species, the vascular bundles in the outer part of the culm-wall are built up by the central strand and several small fiber bundles. *S. diffusum* has its fiber bundles located above and below the phloem and the intercellular space, and laterally on both sides of the vessels. Both metaxylem caps are fused into a single cap. The shape and arrangement of the vascular bundles differ only slightly throughout the height of the culm, while their size decreases. On the whole, the content of vascular elements in the climbing bamboo species is significantly more than those in the erect species, whereas the fiber content is much less.

DISCUSSION

Erect and climbing bamboo species represented by *B. vulgaris*, *B. vulgaris* var. *striata*, *D. merrillianus*, *D. scandens*, and *S. diffusum* were anatomically investigated to determine the possibility of identifying and segregating one from the other. Moreover, the general gross anatomical structure of the erect bamboo group was compared with the climbing bamboo group in the search for significant differences between them. The results of this study

justify the feasibility of segregating and identifying *B. vulgaris* and *B. vulgaris* var. *striata* from *D. merrillianus*. However, between the two closely related *Bambusa vulgaris* varieties, no significant anatomical differences exist The climbing bamboos are hardly segregated from one another, as revealed by the similarity in anatomical structure of the two species examined.

Of particular interest is the fact that erect bamboos can be easily differentiated from climbing bamboos. The vascular bundles of the former could be classified into four general types (Types I, II, III, and IV, Figs. 2*a*-2*d*), thus facilitating the segregation and identification of most of the bamboo species [Grosser (1970)]. However, those of the climbing species could not be classified into definite types, thus making it difficult to differentiate one species from the others. In erect bamboos, there is a great variation in anatomical structure from internode to internode of a given culm, but less differentiation in climbing bamboos. Significantly, climbing bamboos have a higher content of vascular elements (vessels, sieve tubes) but lower in fiber content than erect bamboos.

Based on the anatomical structure, *B. vulgaris* is easily identified from *D. merrillianus*. The former generally possesses small vascular bundles predominantly of Type III and seldom of Type IV. In *D. Merrillianus* one type exists only in the base internodes near the ground, with wall thickness, ranging from 15 to 17 mm or more. Furthermore, the occurrence of simple fiber groups between the vascular bundles in the peripheral region of the middle and top internodes identifies the species from *D. merrillianus.*

In contrast, *D. merrillianus* has larger vascular bundles, belonging to Type IV. Vascular bundles of Type III are found only in the uppermost internodes, aside from those of Type IV. Unlike in *B. vulgaris* the innermost vascular bundles of the middle and top internodes of *D. merrillianus* often show small inner and outer fiber bundles. In the transitional region, the phloem and xylem caps are very large and hooklike. The outer vascular bundles of the peripheral region are generally smaller than in *B. vulgaris.*

As a whole, the anatomical structure of climbing bamboos is completely different from erect bamboos The vascular bundles of climbing bamboos in the middle and inner part of the culm-walls consist of two extremely large metaxylem vessels, a large long-oval phloem, and only a small intercellular space. In

addition, the fiber tissue consist of very small sheaths and thin, sickle-shaped fiber bundles, unlike those of erect bamboos. With regards to the two climbing bamboo species, *D. scandens* and *S. diffusum* have no distinct anatomical differences to identify or segregate them individually.

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ILLUSTRATIONS

PLATE 1

FIG 1. Transverse section of *Dendrocalamus strictus* (Roxb.) Nees, 2.5 ×. (From Grosser, Beitrag zur Histologie und Klassifikation asiatischer Bambusarten, Hamburg, 1970.)

2. Vascular bundle of bamboo: *a*, phloem; sieve tubes with companion cells; *b*, vessels; *c*, intercellular space with a ring of protoxylem elements; *d*, parenchymatous tissue.

PLATE 2

(Climbing bamboo species.)

FIG. 1. *Dinochloa scandens;* middle internode, 16 ×.

2. *Schizostachyum diffusum;* top internode, 16 ×.

3. *Schizostachyum diffusum;* base internode, 27 ×.

PLATE 3

(Erect bamboo species.)

FIG. 1. *Bambusa vulgaris;* base internode, 11.5 ×.

2. *Dendrocalamus merrillianus;* base internode, transitional region,

3. *Dendrocalamus merrillianus;* base internode, central region, 11.5 ×.

PLATE 4

(Transverse section of *Bambusa polymorpha* Munro -- base internode, 6.5 ×. From Grosser, Beitrag zur Histologie und Klassifikation asiatischer, Humburg, 1970.)

FIG. 1. Peripheral region.

2. Transitional region.

3. Central region.

4. Inner region.

PLATE 5

Bambusa vulgaris Schrad. ex Wendl. Transverse sections representing different internodes of a culm.

PLATE 6

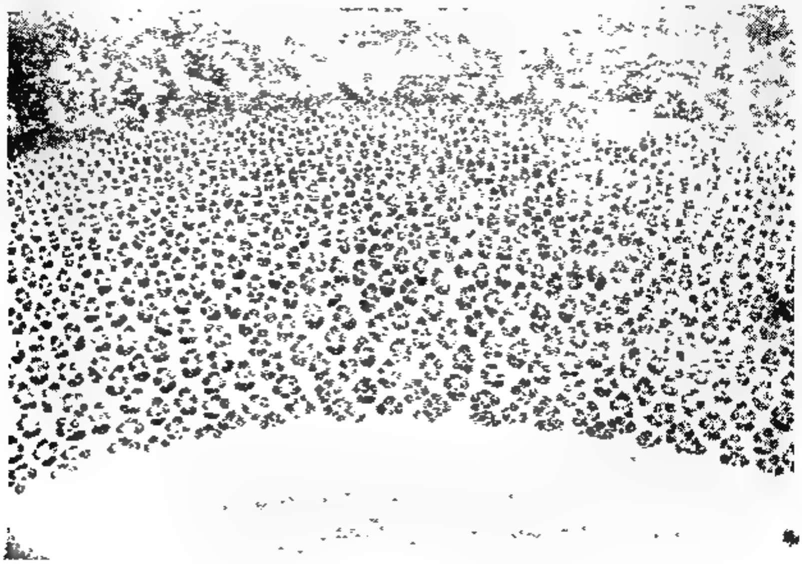
Diagram of vascular bundles of *Bambusa vulgaris* Schrad. en Wendl.

PLATE 7

Dendrocalamus merrillianus. Transverse section representing different internodes of a culm.

PLATE 8

Diagram of the vascular bundles of *Dendrocalamus merrillianus* (Elm.) Elm.



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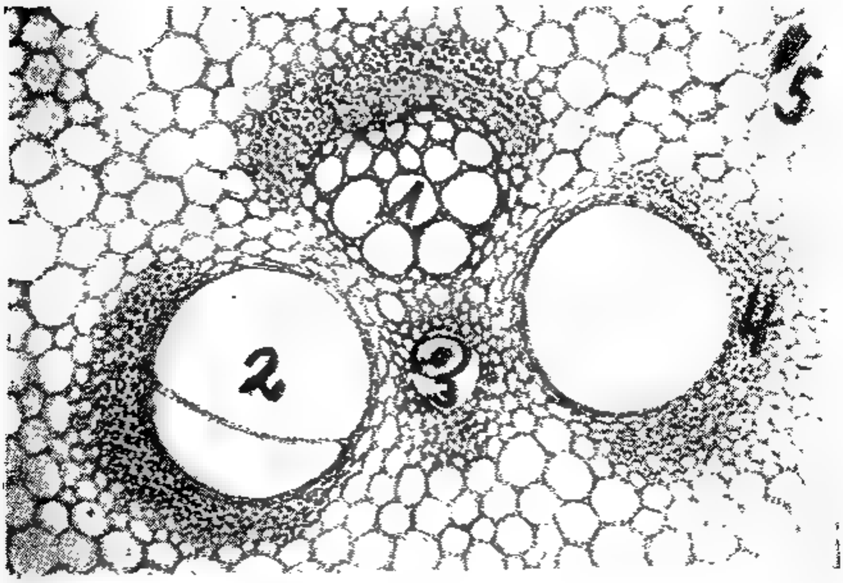

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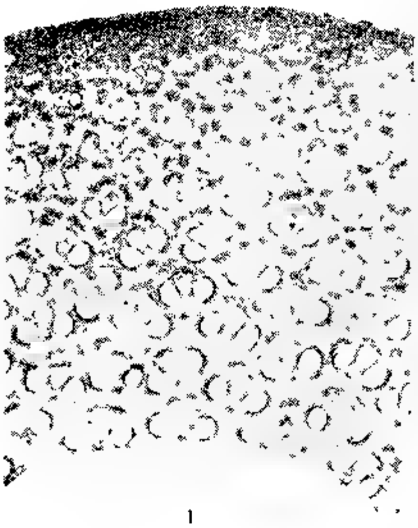

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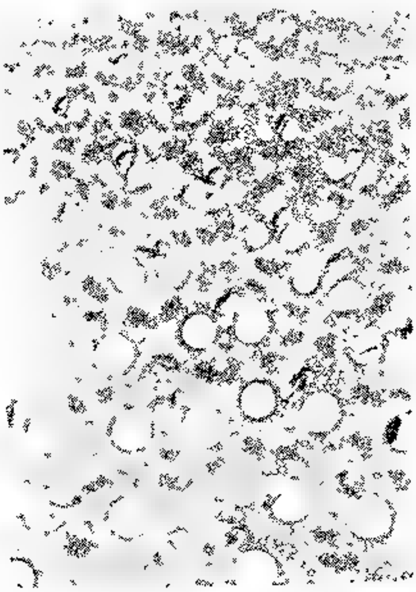

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PLATE 2.

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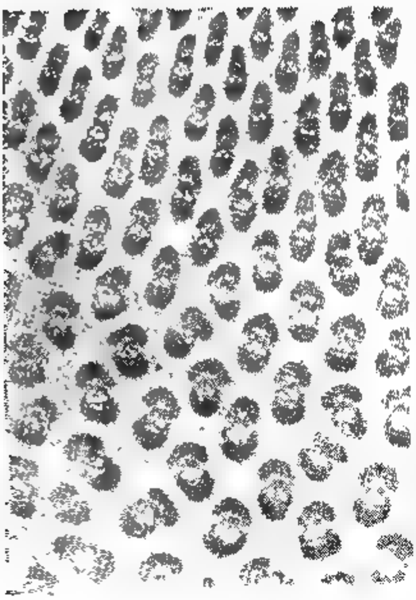

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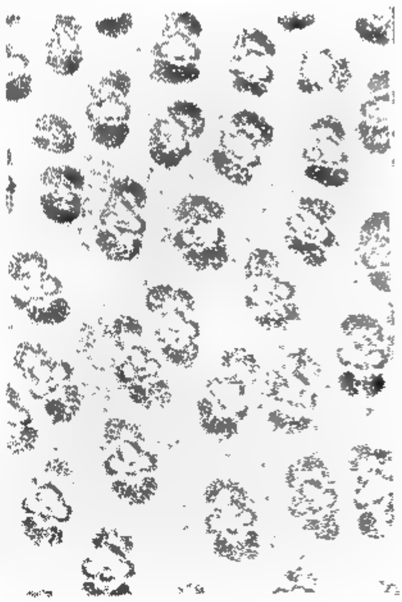

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PLATE 3.

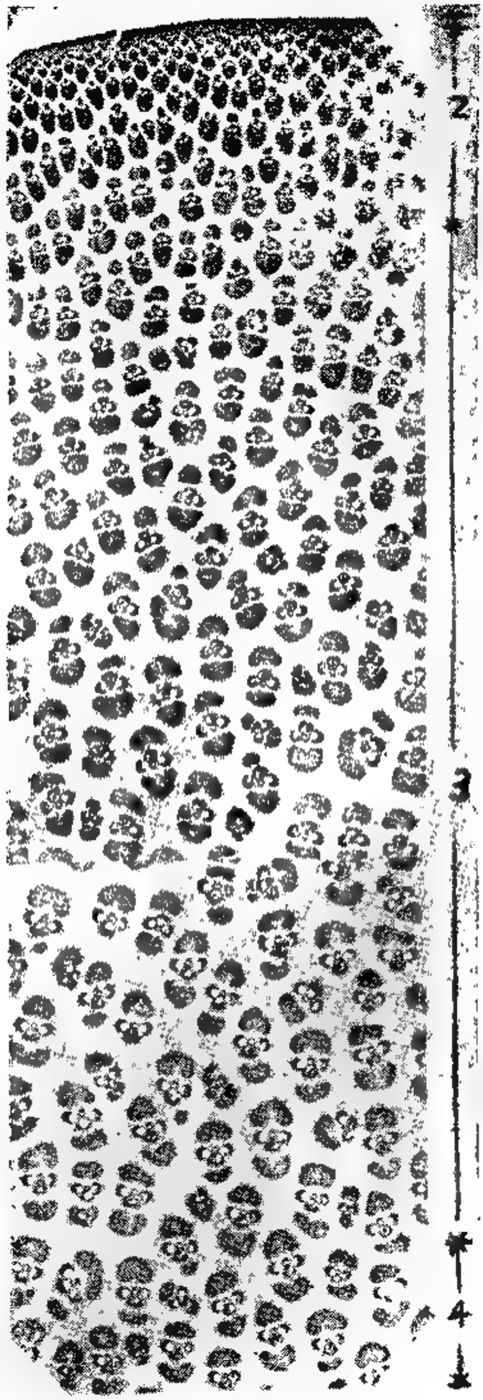
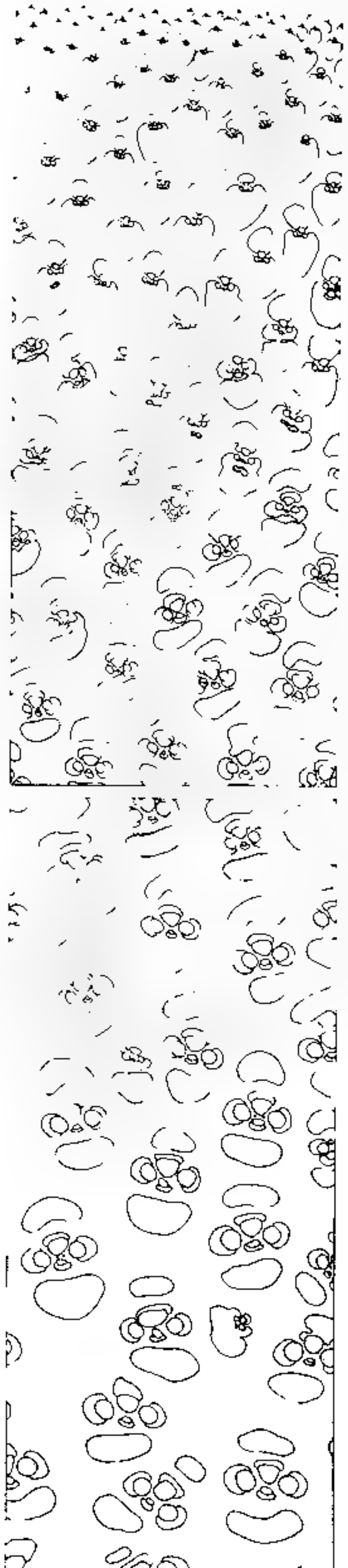
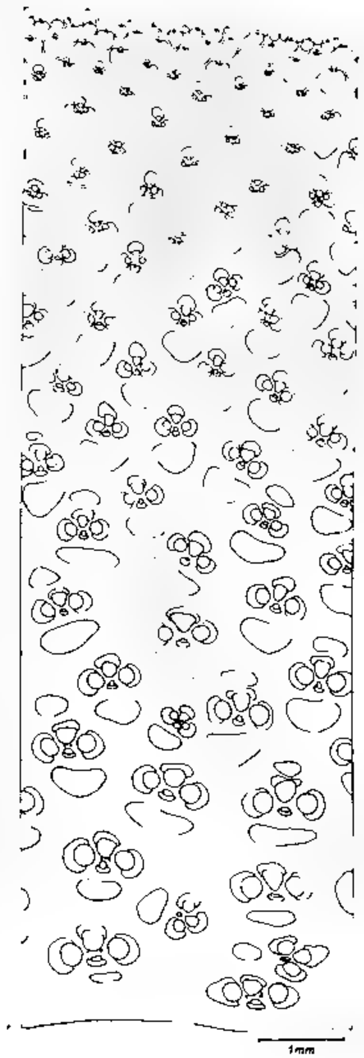
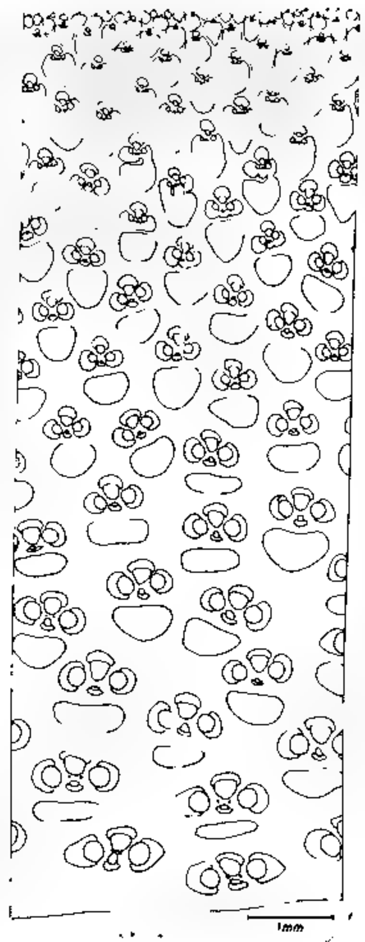

2
3
4
peripheral region
transitional region
central region
inner region

PLATE 4.

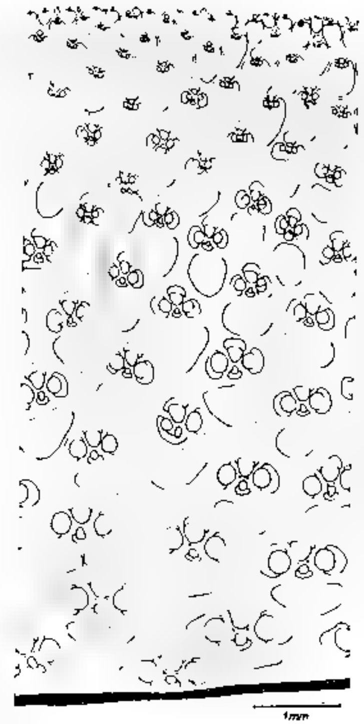




6 internode

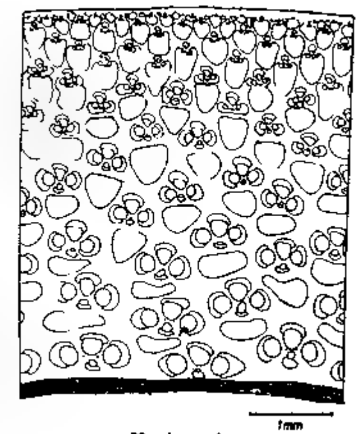


10 internode



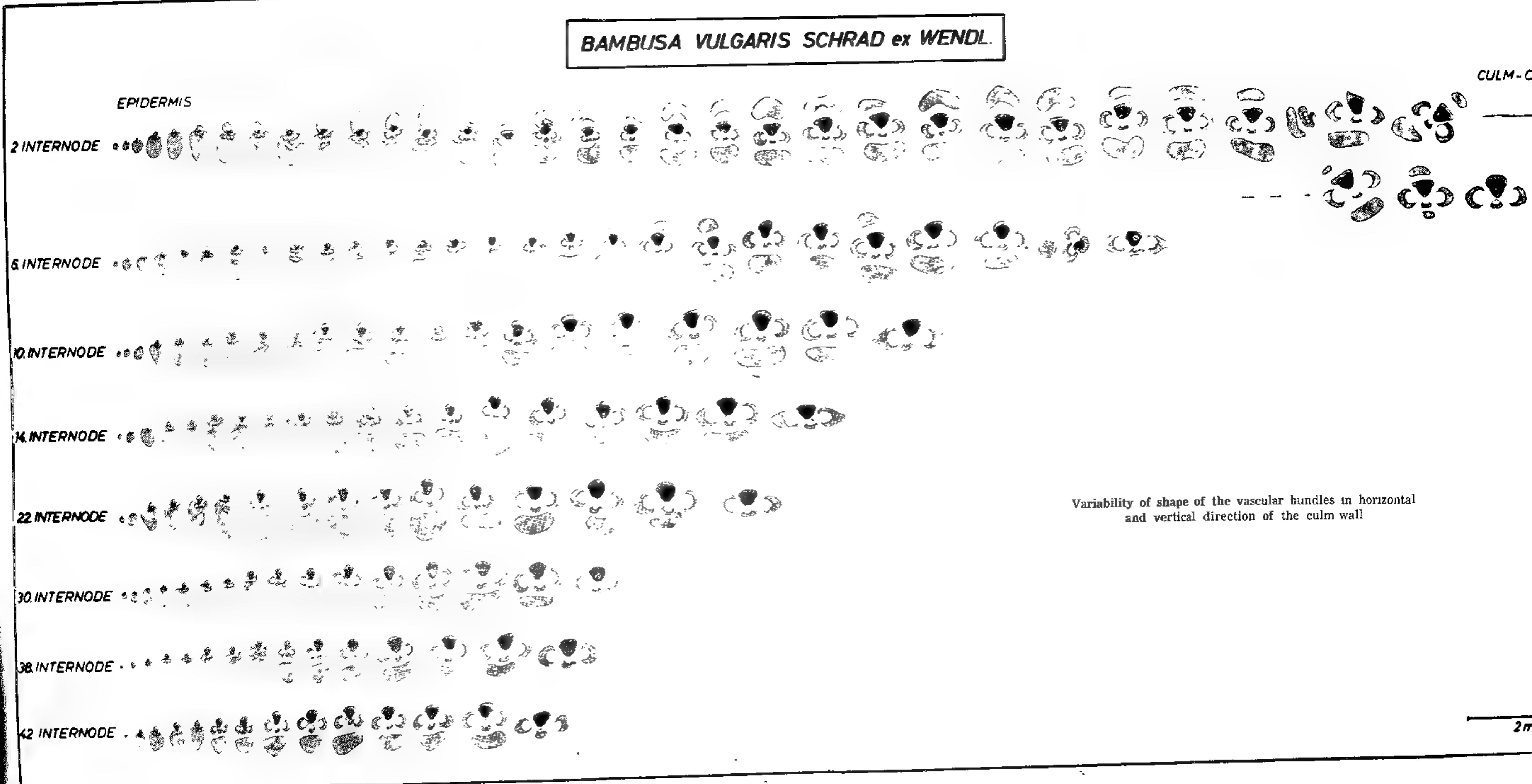
18 internode

26 internode



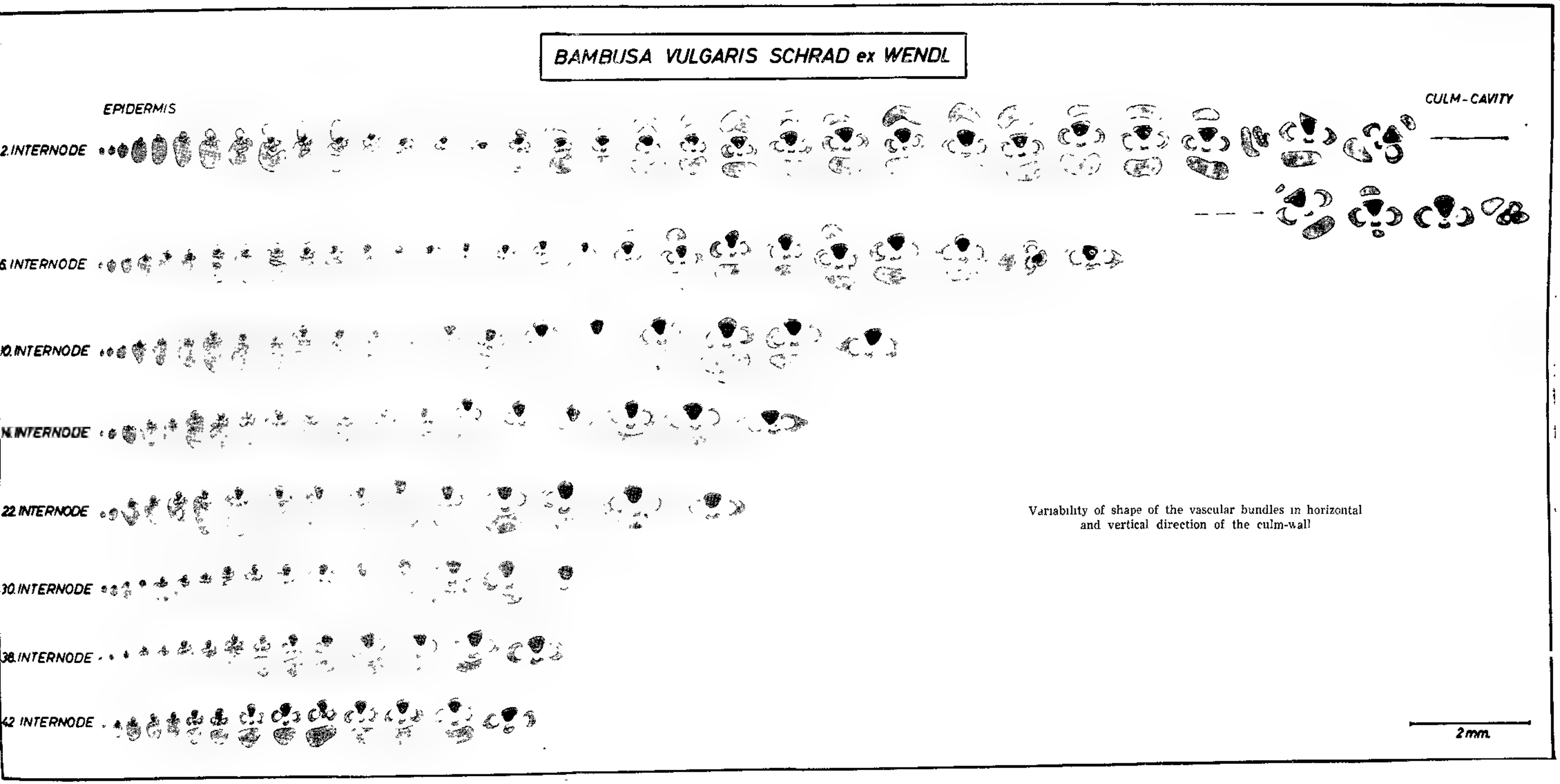
38 internode

Bambusa vulgaris Schrad ex Wendl (Transverse sections representing different internodes of a culm.)



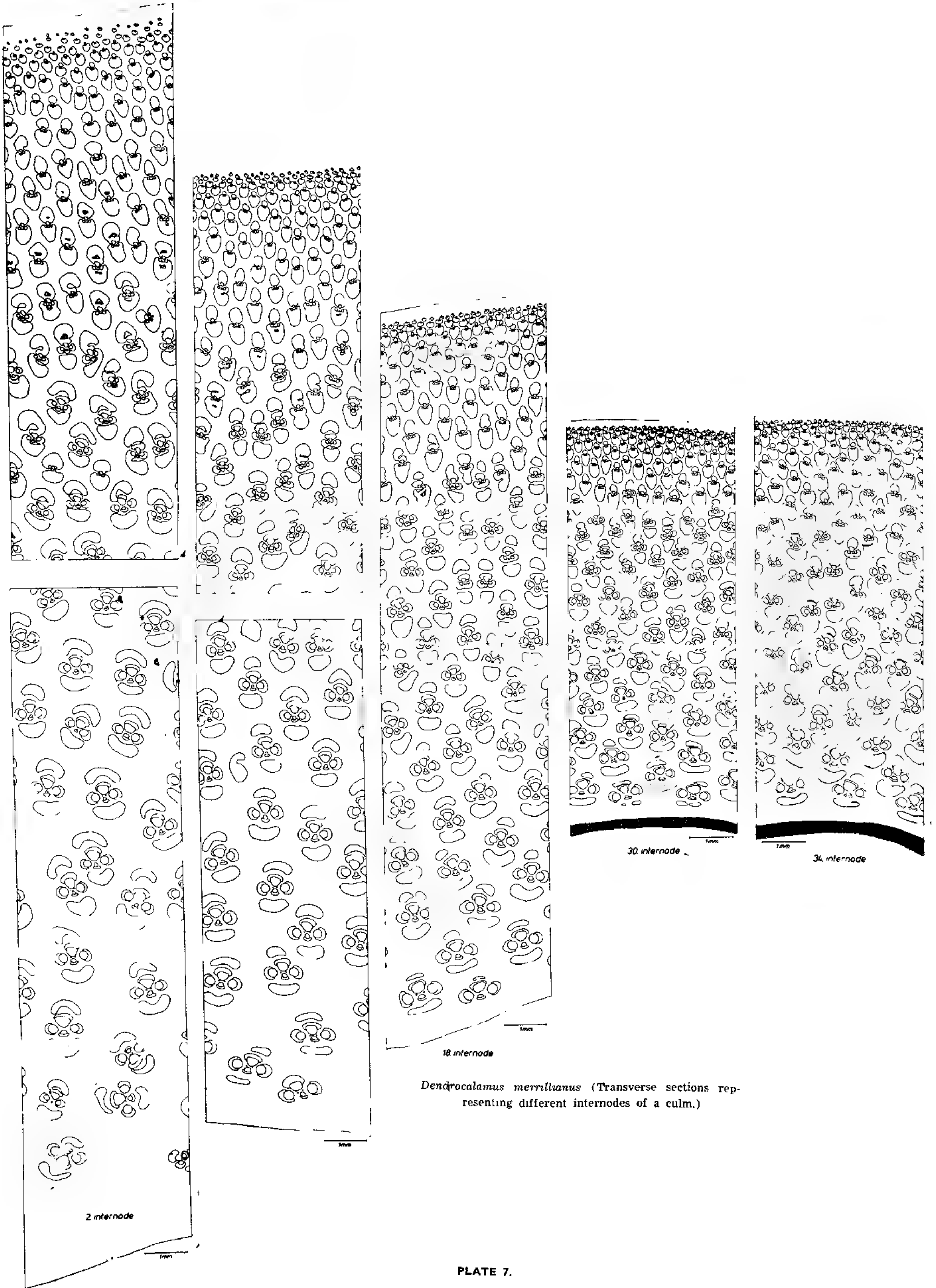
Variability of shape of the vascular bundles in horizontal and vertical direction of the culm wall

PLATE 6.



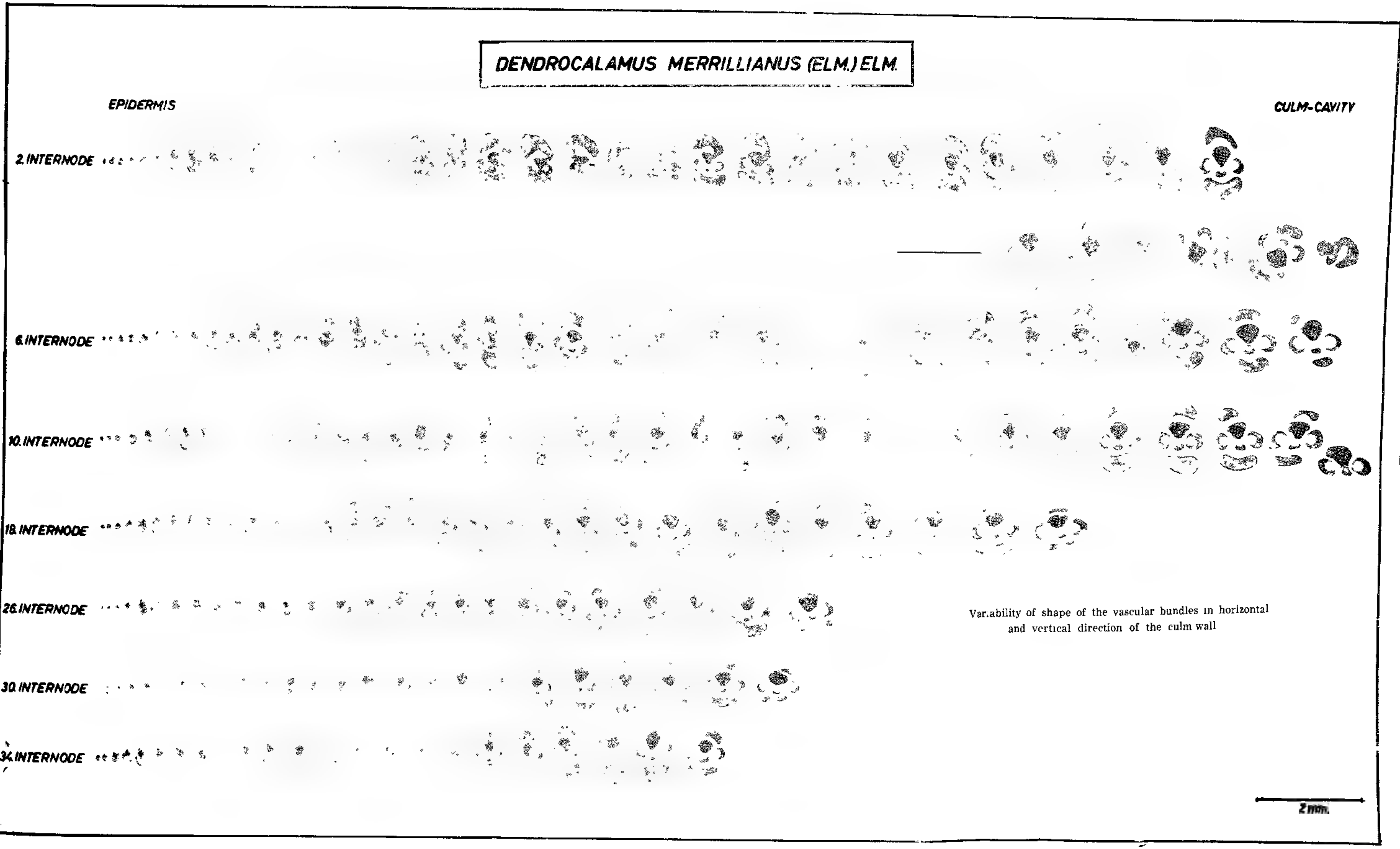
Variability of shape of the vascular bundles in horizontal and vertical direction of the culm-wall

PLATE 6.



Dendrocalamus merrillianus (Transverse sections representing different internodes of a culm.)

PLATE 7.



Variability of shape of the vascular bundles in horizontal and vertical direction of the culm wall

PLATE 8.

REVIEW OF ACCOMPLISHMENTS OF THE NIST ALLERGY UNIT AND CONTRIBUTING INVESTIGATORS

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ABSTRACT

The Allergy Unit, Medical Research Center of the National Institute of Science and Technology, had been conducting simultaneous coordinated studies of local material by the botanical, chemical and medical phases to achieve a practical approach for the diagnostic and treatment purposes on respiratory allergy. Consolidated accomplishments of these different phases are compiled to serve as a compact reference.

INTRODUCTION

In our country, there is a dearth of research studies in the field of allergy. With the advancing frontiers of medical science, there is an incomprehensible gap created which is irreconciliably incompatible with relatively advanced stages of scientific development in other areas of medicine. This inexplicable disregard of allergy is not only unjustifiable but regrettable.

It is not only this inexplicable disregard of allergy based on the recognition of the indispensability of science to the development efforts of modernizing nations, but there is also need in our country of national scientific development in this area of medicine for economic reasons. The allergic diseases were becoming recognized as a problem. The great economic loss due to the patient's inability in many instances to carry on daily duties makes the disease an important public problem. Furthermore, from the standpoint of suffering and annoyance, the importance of this ailment [Feinberg (1946)], such as bronchitis, rhinitis, asthma, urticaria, etc., if inadequately controlled over the years, is its tendency toward complications which can make the sufferers pulmonary invalids.

Consequently, even for the afore-mentioned reasons alone, the NIST was impelled to take appropriate measures a few years ago to supplant straightway this indifferences towards allergy with the interest that it deserves.

Our purpose in this paper is to provide a coordinated picture of the practical approach in the researches of respiratory allergy conducted by the NIST and contributing investigators based on whatever data are available of the botanical, chemical and medical efforts, combined simultaneously. We shall attempt

also to present the compiled accomplishments which revealed the realization of this pioneering allergy research program conducted at the NIST laboratory.

BOTANICAL PHASE

Botanical surveys and æro-palynological studies (daily pollen incidence) were done. From these studies data of the geographical distribution and sectional preponderance of local pollen producing plants especially of the grass and some weed families in the city of Manila and Makati areas have been done.

From Payawal and Laserna's (1965) field survey of the Manila area in 1961-62, the widely abundant species were: Bermuda grass (*Cynodon dactylon*), yard grass (*Eleusine indica*), and talahib (*Saccharum spontaneum*). In 1963 their æro-palynological survey [Payawal and Laserna (1966)] showed that the predominant pollen grains in the Manila area were Gramineæ, Moraceæ, Urticaceæ, Mimosa pudica, and Myrtaceæ.

From the field survey by Remo and Laserna (in press) at the Makati area for 1968-69. the widely predominant grasses were yard grass (*Eleusine indica*) and alabang x (*Dicanthium aristatum*). The æro-palynological study [Remo and Laserna (in press)] on the other hand, showed that the predominant pollen grains were Gramineæ, Moraceæ, Laguminosæ, and Myrtaceæ.

A knowledge about geographical distribution and the relative kind and abundance of various species as well as their habits of pollen maturation and the effect of weather in atmospheric dispersal is essential for successful therapy, for correlation of pollen fluctuations and symptom of patients.

Results of the studies on the botanical survey and daily atmospheric counts; largely accomplished by the botanist, are of great assistance to the allergist in his evaluation of the role and relative importance of airborne substances in the production of allergic diseases in a given locality in the analysis of his diagnostic and therapeutic success or failures.

CHEMICAL PHASE

Preparation of selected extracts giving priority to the commoner and clinically more important allergens were done. Pollen extracts for skin and treatment purposes are aqueous extracts of whole pollen. Extracts of dependable quality have been prepared and standardized [Laserna and Manalo (1966)] by the determi-

nation of protein nitrogen for potency. In order to preserve the aqueous extract from deterioration; these were lyophilized.[1]

The rate of deterioration of the potency of each extract was restandardized by the determination of the protein-nitrogen content from both the liquid and lyophilized extracts. These are given in Table 1.

TABLE 1.—*Local allergenic extracts — prepared and standardized for potency (after Manalo and Laserna)*

Pollen allergenic extracts	1970 Protein N/cc	1970 Lyophilized in 5 cc	1971 Protein N/cc	1971 Lyophilized in 5 cc	1971 Protein N/cc	1971 Fluid in 50 cc
	mgm	No. of vials	mgm	No. of vials	mgm	No. of vials
Yard grass	0.200	6	0.110	70	0.150	2
Amorsecos		1	0.125	70	0.190	1
Alabang x			0.120	70	0.205	11
Urai	0.095	25	0.070	71	0.140	9
Carabao grass = Paspal[illegible]	0.076	3				
Bermuda grass	0.105	18	0.085	71	0.140	4
Crab grass = [illegible]	0.070					
Foxtail	0.130	9				
Java grass	0.110	4				
Kogon	0.155	2				
Mais	0.265	23				
Mimosa	0.03[illegible]	21				
Natal	0.[illegible]45	6				
Oil palm		5				
Para grass = Brach[illegible]		1				
Rice	0.140	6				
Sugar cane	0.1[illegible]5	1				
Sunflower	0.130	13				
Talahib	0.125	8				
Tri[illegible]ax	0.185	29				

A selected number of pollen collected from the most common local allergenic plants were extracted and standardized. Re-standardization for potency of these extracts underlines one of its activities.

MEDICAL PHASE

Part I — skin test.—The subjects are individuals with clinical conditions which includes hay fever especially with respiratory manifestations of asthma, bronchitis, rhinitis or a combination of these allergies. History of each patient is carefully taken in detail. Physical examination is done before each patient is given the skin tests (scratch or intradermal) for diagnosis of allergic diseases with diluted extracts. Control subjects are individuals free of any kind of allergies.

The skin test has been the most important single influence in the development of the subject of allergy. In allergic disorders

[1] Lyophilization was done at the Bureau of Animal Industry, Pandacan, Manila

of the respiratory tract, the use of skin tests yield the most satisfactory results [Cooke (1947)].

a. Vivera (1966) made skin tests to our limited local pollen extracts. Out of the list of NIST pollen allergens, 18 pollen extracts elicited 12 positive reactions on skin testing, Table 2.

TABLE 2.—*Reactions to local pollen extracts skin-tested by Vivera.*

Local name	Intensity of skin reactions and number of individuals reacting positively			
	Slight positive	Moderate	Marked	No. of points of positive reactions
Alabang x		1		1
Amor-secos	2	5		7
Batad-batadan	3	1		4
Bermuda	11	6		17
Foxtail millet	1	1		2
Java grass	1			1
Kogon		1		1
Mutha	1			1
Talahib	2	2		4
Tridax	1			1
Urai	4	6		10
Yard grass	1	2	1	4

b. Dacanay (1969) carried out the skin test on 120 patients. Out of 22 pollen extracts, seven gave over 50-per cent positive reactions, Table 3.

TABLE 3.—*Reactions of 120 patients skin-tested by Dacanay.*

Local name	Per cent of positive reactions
1. Yard grass 2. Amor-secos 3. Alabang x 4. Urai 5. Carabao 6. Bermuda 7. Crab grass	over 50
8. Para grass 9. Mutha 10. Natal 11. Guinea 12. Java grass	over 30
13. Batad-batadan 14. Tridax 15. Sunflower 16. Kogon 17. Mimosa 18. Talahib 19. Mais 20. Rice 21. Foxtail 22. Sugar cane	11.7 - 28.3

The evidence of constitutional symptoms in the skin tests carried out by Vivera and Dacanay with NIST produced pollen extracts suggested that some pollen antigens from grasses and weeds in our country might be important respiratory allergens, some more potent than others The diagnosis obtained by Vivera giving positive reactions to 12 pollen allergens was narrowed down to only four: Bermuda grass (17 positive reactions), urai (10), amor-secos (7); and yard grass (four positive but one marked reaction). Dacanay's list of pollen extracts of plants giving over 50-per cent positive reactions to skin test was also chosen but in the reverse order; namely, yard grass, amor-secos, alabang x, urai, and bermuda grass.

Reasons for selecting these five pollen extracts are as follows: they gave the most number of positives in the skin test in the order named; they were the most abundant plants in the area; carabao grass and crab grass were not included because their flowering seasons coincided with other more abundant grasses; furthermore, the selection agrees with the results of pollen production studies [Manalo, Payawal, and Laserna (1969)] which takes into account pollen size, plant height, and the number of pollen produced per floret as shown in Table 4.

TABLE 4—*Plants which gave over 50-per cent positive reactions (after Manalo and Laserna).*

Common name	Scientific name	Total rating of pollen production	Number of pollen per floret
Yard grass	*Eleusine indica*	5	332
Amor-secos	*Andropogon aciculatus*	6	1,869
Alabang x	*Dicanthium aristatum*	4	3,468
Urai	*Amaranthus spinosus*	8	12,692
Carabao grass	*Paspalum conjugatum*	4	295
Bermuda grass	*Cynodon dactylon*	5	804
Crab grass	*Digitaria microbachne*	3	322

Part II—Hyposensitization (treatment)—The results of the treatment will depend on the reactions of the patients, whether desensitization is the complete loss of, or partial diminution in the hyposensitive state.

In order to fully evaluate the results of grass and weed pollen treatment, a full year of hyposensitization therapy given at weekly intervals was done on 40 patients. So far only 15 research patients completed 1-year treatment, the rest has still to undergo

6 months of hyposensitization treatment; before a complete evaluation of said extracts could be obtained.

The resulting observations from this study will be of tremendous importance as this will determine the efficiency of the extracts in the treatment of allergic patients.

SUMMARY

Every little bit of information is contributory to furthering researcher's efforts to promote in the analysis of a successful problem. A survey of literature reveals that the Allergy Unit of the Medical Research Center, National Institute of Science and Technology, with some contributing investigators have realized the pioneering coordinated research studies on respiratory allergy, although in a limited scale, through the combined efforts of the botanical, chemical and medical phases. We trust that the following articles presented here, a compilation of these data as accomplishments will facilitate reference of the different phases (botanical, chemical, and medical) of the studies on respiratory allergy.

ACKNOWLEDGMENT

For the realization of this pioneering allergy research program, deep appreciation is due to Dr. Frank Co Tui, Dr. Arturo B. Rotor, and Dr. Eduardo Quisumbing for their guidance and valuable advice; to Dr. Arsenio B. Vivera, allergist, for his unselfish interest in providing us this allergy research program; to Dr. Rogelio N. Relova for his encouraging support; to Dr. Eleonora P. Dacanay, Mrs. Josefina B. Manalo, Miss Irma C. Remo, Mr. Pacifico C. Payawal, and Lourdes M. Artiaga for their dedicated interests and efforts in performing the researches; and to Emiliano Villagracia and Delfin C. Castillo for their help in the collection of pollens from local allergenic plants for our study material.

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